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SUDBURY ENVIRONMENTAL STUDY

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METEOROLOGY PROGRAM

REPORT NUMBER ARB-009-81-ARSP

September, 1981

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Ontario
Ministry of the Environment

The Honourable
Keith C. Norton, Q.C.,
Minister

Gérard J. M. Raymond
Deputy Minister

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SUDBURY ENVIRONMENTAL STUDY

METEOROLOGICAL PROGRAM

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SUMMARY

From September 1976 to September 1979 a meteorogical measurment program was carried out in the Sudbury area. The objectives of the program were twofold:

1. to determine the meteorological characteristics most affecting the dispersion and dry deposition of locally emitted pollutants
2. to provide a data base for the development of computer dispersion and deposition models.

The program consisted of daily releases of pilot balloons and minisondes for the measurement of the vertical wind and temperature structure of the lower atmosphere.

After a significant data base was accumulated, it was decided that detailed analyses should focus on characterizing the convective boundary layer (or mixed layer) in the local area.

The results indicate that the characteristics of the mixed layer play a major role in determining the dispersion and dry deposition of local pollutants in the Sudbury area from May through September.

The average mid-day mixed layer height over the study perioc was 1040 m above ground level and the maximum height was 2328 m. The mixed layer winds showed an increased frequency from the west. Westerly component winds had an average speed of 6 m/s which was approximately twice as great as that for the easterly component winds.

The layer above the convective boundary layer capping inversion had an average potential temperature gradient of $3.3^{o}C/Km$.

The average incoming solar flux over the mid-day hours (1100-1500 hr) averaged for May through September ranged from 600 to 800 W/m^2. Those days with known convective activity produced an average mid-day solar flux 50 to 250 W/m^2 greater than the mean for all days.

The effect of the convective boundary layer on the disperson of locally emitted pollutants has been observed to be quite significant. The data obtained in this program have been used in the development of several computer models to simulate both the dispersion and dry deposition of these emissions.

CONCLUSIONS

Data from the Sudbury Environmental Study Meteorological Program have been analysed to characterize the behaviour of the mixed layer in of the Sudbury area. Several conclusions have resulted from the program.

- The mean mid-day mixing height for the months of May through September was approximately 1040 m above ground level. The mixed layer height was relatively constant though June, July and August and was slightly lower in May and September.
- The maximum mid-day mixing height measured during the program was 2328 m above ground level. The maximum for each month varied quite significantly.
- The greatest variability in mid-day mixing heights occurred in the months of May and June.
- Mixed layer winds in the May to September period showed a predominant wind speed of 4 to 6 m/s. Westerly component winds had a frequency roughly four times greater than easterly component winds and the wind speeds associated with the two components were noticeably different. For the period from May to September, the average mixed layer wind speed for westerly component winds was 6.4 m/s while that for easterly component winds was 3.8 m/s. The differences in both the frequency and speed of the mixed layer winds have major implications on local air quality and dry deposition.
- The upper level inversion above the mixed layer capping inversion had a mean mid-day potential temperature lapse rate of 3.3^{o}C/Km over the study period.

- Mean values of total incoming solar radiation during mid-day hours (1100-1500 hr) averaged from May to September were in the range of 600 to 800 W/m^2. Monthly maximum values were 200 to 500 W/m^2 greater than monthly means. For days with known convective activity, the monthly means were 50 to 250 W/m^2 greater than the mid-day means obtained using data from all days.

- The convective boundary layer is a signficant daytime meteorological characteristic of the Sudbury area. It occurs on relatively sunny days from May through September. Locally emitted pollutants released into the convective boundary layer behave in a manner known as looping. This is caused by large-scale convective turbulence and ultimately results in the rapid mixing of the emissions throughout the entire layer, and high ground level concentrations near the stack. Because the average mixing height is over two and one half times the height of the INCO 381 m stack, dispersion of emissions from the tall stack is quite sensitive to the existence of the convective boundary layer.

1. INTRODUCTION

From September 1976 to September 1979 the Air Resources Branch carried out a specialized meteorological measurement program in the Sudbury area. The objectives of the program were twofold, namely:

1. To provide information on the meteorological characteristics of the Sudbury area in order to evaluate their impact on the dispersion and dry deposition of locally emitted pollutants.
2. To provide a meteorological data base for the development of computer models designed to assess the fate of locally emitted pollutants.

The program consisted of the measurment of wind speed, wind direction and temperature in the vertical using a pilot-balloon minisonde system. The balloon releases were carried out twice daily - once in the early morning and once in the early afternoon -under fair weather conditions. The balloons were tracked using dual theodolites. Data analysis was carried out in Sudbury using a Hewlett-Packard 9825 computer. During the last year of the program, total incoming solar radiation measurements were also made as part of this program.

A preliminary assessment of the meteorological data base indicated that the program should focus on characterizing the meteorology of the Sudbury area during summer months. The rationale for this is based on the dispersion of local emissions in the convective boundary layer (CBL) which is formed during these months (May through September). The convective boundary layer

is defined as that portion of the atmosphere affected by heating of the earth's surface. This heating results in large scale convective turbulence which, in turn, causes vigourous vertical mixing of the atmosphere. The term 'mixed layer' comes from this characteristic of the CBL and is used interchangeably with it. The mixed layer is generally limited to the first two kilometers above the earth's surface.

Pollutant plumes emitted into the convective boundary layer behave in a characteristic manner described rather graphically as 'looping'. This behaviour is caused by portions of the plume being emitted into the large scale turbulent updrafts and downdrafts of the convective atmosphere. Under these conditions, portions of the plume can be brought to the surface very close to the stack resulting in high ground level concentrations. The existence of the convective boundary layer and the looping of plumes has long been noted in the Sudbury area. It appeared to be especially important for the INCO 381 m stack which is the major emitter in the area since in general during convective conditions in the summer months the plume from this stack was observed to impinge most frequently at ground level. Thus, the impact of the emissions from this source on both air quality and dry deposition in the Sudbury area is related to the formation of the convective boundary layer. It was therefore decided to concentrate the data analysis on producing a statistical analysis of the convective boundary layer in Sudbury during the summer months.

This report describes the field measurment program, the data analysis methods and the analysed characteristics of the mixed

layer. While the statistical results are sometimes referred to as a climatology in the body of the report, it should be pointed out that the time period and the frequency of measurements were insufficient to make this a complete climatology and care should be used in extrapolation.

A detailed description of the diurnal behaviour of the mixed layer and its impact on local air quality is published elsewhere (1). Two intensive field studies were carried out in the Sudubry area precisely for that purpose. The data obtained in those studies provided an extremely useful base for guiding the analysis presented in this report.

2. FIELD MEASUREMENT PROGRAM

The meteorological field measurement program began in September 1976 and continued until September 1979. It consisted of two components, namely, the measurement of wind speed, wind direction and temperature in the vertical and the measurement of surface solar radiation. Both measurements were designed to provide a statistical data base from which climatological characteristics of the convective boundary layer in Sudbury area could be determined.

The two measurement programs are described below.

2.1 Vertical Wind and Temperature Measurements

A pilot-balloon minisonde system was used for the measurement of wind and temperature in the vertical. The instrumentation consisted of the following:

Aero Aqua 30 gm pilot balloons

Aero Aqua Minisonde Transmitters

Aero Aqua Model AAI 3001 Minisonde Receiving Station

Warren-Knight Pilot Balloon Theodolites

Sangamo Minisonde Transmitters

Climatronics Mini-Met Sonde (MMS) System

Weathermeasure BM70 Micro Aneroid Barometer

Motorola FM transmitter/receiver and walkie-talkies

The measurements were done as follows:

a) A pilot balloon was filled with helium to a calibrated lift of 3 ms^{-1}.

b) A minisonde was attached to the balloon at the end of a 3 m length of string.

c) The sonde was adjusted to transmit at a central frequency of 403 MHz.

d) The ground level temperature near the sonde was measured (using a digital thermometer) and noted on the chart recorder output of the minisonde receiving station. Ground level pressure was also measured and noted.

e) Observations were made on the cloud cover, the weather, and the INCO 381 m stack plume behaviour and direction.

f) Two Warren-Knight Pilot Balloon Theodolites were set up at the ends of a 300 to 400 m baseline oriented approximately perpendicular to the wind direction.

g) The two theodolites were levelled and sited on each other. The angle above or below the horizontal (i.e. the ground plane angle) was measured and noted by each theodolite operator.

h) Both theodolites were sighted on the balloon at its position before release. These initial azimuth and elevation angles were recorded on cassette tape recorders.

i) The balloon was released. Every thirty seconds during the ascent, the position of the balloon in space was marked by measuring the instantaneous azimuth and elevation angles from the theodolites and recording them on tape. Also, at 15 second intervals, a timing mark was placed on the chart record output of the minisonde receiver. From 1976 to 1977, the Climatronics Mini-Met Receiver was used with Sangamo sondes. This system required an operator to keep the chart record on scale, to mark the 15 second time intervals on the chart record and to broadcast the 30 second timing marks to the theodolite operators. In 1978, the Aero Aqua system was

implemented. The timing requirements were automated with this system and no operator was required for the minisonde record. The entire release operation changed from a three-to a two-man operation.

j) The balloon was sited every 30 seconds until it was no longer in view of both theodolites. The minisonde signal was recorded until it was lost.

Balloon releases were carried out on weekdays only (except during intensive field studies) under non-precipitating conditions. Under ideal conditions, two releases were carried out daily -- one in the early morning immediately after sunrise to measure nocturnal conditions and the second in the early afternoon-1300 to 1400 hours local time to measure daytime conditions.

The location and details of the 4 baselines used throughout the study are indicated in Figure 1. All were located within 5 Km of the INCO 381 m stack. Baselines 3 and 4 were most frequently used during the program.

Figures 2 to 4 show the instrumentation used in the measurement program.

2.2 Solar Radiation Measurements

From June, 1978, to September, 1979, measurements were made of total incoming solar radiation. A Kipp and Zonen Model CM5 Solarimeter with a wavelength range from 300-2500 nm was used. The voltage output was recorded directly on a strip chart recorder. Before being placed in the field, the solarimeter was

calibrated at the Radiation Laboratory of the Atmospheric Environment Service in Downsview, Ontario.

The solarimeter was mounted on top of the pumphouse of the Water Pollution Control Plant on Kelly Lake Road in Sudbury. This location is immediately adjacent to baselines 4 and 5 used in the Pibal-minisonde program.

The 1978-79 solar radiation measurements were augmented by similar measurements made by the Water Resources Branch in the summer of 1977.

3. DATA ABSTRACTION AND PRESENTATION

The data analyses performed to abstract the raw pilot balloon-minisonde data into vertical profiles of wind speed, wind direction and temperature are described in this section. The abstraction methods for solar radiation data are also described. These analyses were the first step in preparing the data for statistical determination of convective boundary layer characteristics.

3.1. Pilot Balloon - Minisonde Data

Abstraction of the pibal-minisonde data from raw to final form consisted of four steps:

1. Raw data transfer to a Hewlett-Packard 9825 computer
2. Data analysis using Thyer's method (2)
3. Re-analysis using data smoothing
4. Printing, plotting and storage of profile information

Each step is described separately.

3.1.1 Data Transfer

After each balloon release, the raw data were transferred from tape recordings and chart records to summary tables. These raw data consisted of the azimuth and elevation angles of both theodolites taken every thirty seconds and the ambient air temperature taken every 15 seconds. Additional observational data were also included.

The information on these summary tables was transferred to a Hewlett-Packard 9825 computer. Entry was done manually at the keyboard. Data storage was originally done on cassette tape but was changed to disc mid way through the program. As the data were being transferred, they were carefully screened by the operator to eliminate obvious errors, i.e. inaccurate or questionable data were either changed to reasonable values (if a straightforward error was made) or eliminated completely.

Table 1 is an example of the tabulated raw data computer output. It contains the following:

a) Date: day/month/year of the release

b) Time: local time of the release

c) Baseline: number, bearing (with respect to true north) and length (in metres).

d) Met Data: wind and cloud conditions

e) Plume data: behaviour and direction of the 381 m stack plume

f) Surface Pressure: millibars

g) Relative Humidity: percentage

h) Column 1: time of the theodolite readings after balloon release (minutes)

i) Columns 2 and 3: the azimuth and elevation angles of theodolite number 1 at each 30 second timing mark (degrees)

j) Columns 4 and 5: the azimuth and elevation angles of theodolite number 2 at each 30 second timing mark (degrees)

k) column 6: the temperature of the ambient air at each 30 second timing mark (degrees Celsius)

l) Column 7: the mid-point temperature taken at the 15 second mark between theodolite readings (degrees Celsius).

3.1.2 Thyer's Analysis

The abstraction of the azimuth and elevation angles to vertical profiles of wind speed and direction was carried out using the method proposed by Thyer (2). For details of the method, the reader is referred to the original publication; however, a brief description is given here.

Thyer's method uses all four theodolite angles to make an optimum estimate of the balloon's position at each measurement interval; it also indicates the probable magnitude of error in its estimates.

The geometry of the double theodolite system is shown in Figure 5. It can be seen that the balloon's position in space can be defined by only 3 variables; however, the two theodolites provide 4 variables (angles) for this purpose. Thyer's method takes advantage of this extra piece of information in calculating the balloon's position.

Referring to Figure 5, one can draw rays from the two theodolites towards the balloon according to the measured azimuth and elevation angles, but the two rays may or may not intersect. In practice, these rays seldom do intersect because of levelling, orienting and collimating errors in the theodolites and/or unsynchronized readings by the two operators, errors in reading the angular scales, and difficulty in pinpointing the balloon position at the timing mark.

Even in the absence of these errors, the limitations of accuracy in the theodolites can result in non-intersecting rays. For example, if the readings are made to the nearest 0.1 degree, then the balloon could be anywhere within a cone of semi-vertical angle 0.05 degree whose axis is the ray from the theodolite to the position determined by the measured azimuth and elevation angles. Using double theodolites, the balloon could be anywhere within the region of intersection of these two cones whose axes are defined by the theodolite angles. One can therefore only calculate a most probable estimate of the balloon position within the region of intersection of the cones.

Thyer uses a vector method to find the line representing the shortest distance of approach between the two rays. He then subdivides this line (known as the 'short line') in the ratio of the diameters of the cones where it intersects them. This point is taken to be the most probable position of the balloon.

In Figure 5, rays AB and DC represent the cone axes from theodolites 1 and 2 respectively. Line BC represents the line of shortest approach between the two cones. By defining each line as a vector, i.e. AB as $\underline{r}_1 (a\underline{i} + b\underline{j} + c\underline{k})$, DC as $\underline{r}_2 (d\underline{i} + e\underline{j} + f\underline{k})$, and BC as $\underline{r}_3 (g\underline{i} + p\underline{j} + q\underline{k})$ it is possible to derive the coordinates of the most probable position of the balloon as:

$$x = \underline{r}_1 a + \rho \underline{r}_1 / (\underline{r}_1 + \underline{r}_2)\, g \qquad (1)$$

$$y = \underline{r}_1 b + \rho \underline{r}_1 / (\underline{r}_1 + \underline{r}_2)\, p \qquad (2)$$

$$z = \underline{r}_1 c + \rho \underline{r}_1 / (\underline{r}_1 + \underline{r}_2)\, q \qquad (3)$$

where

$$g = \alpha / \Delta \qquad (4)$$

$$p = \beta / \Delta \qquad (5)$$

$$q = \gamma / \Delta \qquad (6)$$

and

$$\alpha = \sin E_1 \cos E_2 \cos A_2 - \cos E_1 \cos A_1 \sin E_2 \quad (7)$$

$$\beta = \cos E_1 \sin A_1 \sin E_2 - \sin E_1 \cos E_2 \sin A_2 \quad (8)$$

$$\gamma = \cos E_1 \cos A_1 \cos E_2 \sin A_2 - \cos E_1 \sin A_1 \cos E_2 \cos A_2 \quad (9)$$

$$\Delta = (\alpha^2 + \beta^2 + \gamma^2)^{1/2} \quad (10)$$

E_1 and E_2 = elevation angles of theodolites 1 and 2 respectively

A_1 and A_2 = azimuth angles of theodolites 1 and 2 with respect to line AD

In addition to the coordinates x, y and z for each double theodolite reading, the method also provides a measure of the relative error in the balloon position:

$$\tau = \rho / (r_1 + r_2) \tan 0.05^{\circ} \quad (11)$$

This, in fact, represents the ratio of the actual uncertainty to the theoretical uncertainty (+0.05 degree).

A computer program was developed in 1977 to analyse the raw data according to this method. The program was continually upgraded throughout the study and is documented in several internal Air Resources Branch reports (3),(4),(5),(6). The program used Thyer's method to calculate the coordinates of the balloon (x,y) at each 30 second interval into the flight. It then calculated wind speed, V_{xy}, as the vector difference between two consecutive readings divided by 30 seconds, i.e.

$$V_{xy} = (V_x^2 + V_y^2)^{1/2} / 30. \quad (12)$$

The wind direction was determined as $\theta = \tan^{-1}(V_x/V_y)$ with the following conventions:

(i) for $V_x > 0$ and $v_y > 0$,

wind direction = bearing to true north (N) + θ + 180 (in degrees).

(ii) for $V_x < 0$ and $V_y > 0$

wind direction = N + θ + 180

(iii for $V_x > 0$ and $V_y < 0$

wind direction = $N + \theta$

(iv) for $V_x < 0$ and $V_y < 0$

wind direction = $N + \theta$

The wind speeds and directions calculated in this manner therefore represent averages over the height interval between two consecutive balloon positions (approximately 90 m). For each calculated wind speed and direction, the program also calculated the relative error using equation (11).

For times during balloon ascents when one or both readings from one theodolite were missing i.e. only single theodolite data were available, the program used a different analysis technique. This technique involved estimating the height, z, of the balloon a the time of the missing reading and then calculating the other two coodinates, (x and y) from the single theodolite data.

The value of z was calculated as plus 30 seconds times the rise of the balloon in the previous interval. Two cases were considered, i.e.

(i) Theodolite 1 data availble:

z estimated

$$x = z (\sin A_1 / \tan E_1) \quad (13)$$

$$y = z (\cos A_1 / \tan E_1) \quad (14)$$

(ii) Theodolite 2 data available:

z estimated

$$x = z (\sin A_2 / \tan E_2) \quad (15)$$

$$y = z (\cos A_2 / \tan E_2) \quad (16)$$

Before the next stage in the data abstraction was initiated, the results of Thyer's analyses were manually screened. If inordinately large values of τ (Eq. 11) were observed or the profiles looked

unreasonable, the input data were eliminated (or in some obvious cases, changed) and the single method was invoked.

The temperature data from the minisondes were incorporated in the analysis by assigning the proper height z to the appropriate temperature measurement.

Table 2 is an example of the output resulting from the analysis using Thyer's method. The following information is included in the output:

(a) Date and Time of Release

(b) Baseline Number, Bearing and Length

(c) Time after release (in minutes)

(d) x coordinate with respect to theodolite 1 (metres)

(e) y coordinate with respect to theodolite 1 (metres)

(f) z coordinate with respect to theodolite 1 (metres)

(g) Height (MSL) = z + 256 metres above mean sea level

(h) Temperature (^{o}C) at each measured z and at each midpoint

(i) Rise Rate (m/s) = z/30 seconds

(j) V_{xy} (m/s): the interval average wind speed between consecutive readings

(k) Wind Direction relative to true north

(l) TAU: the relative error in the measurement. Note that TAU is not available for single theodolite calculations.

In 1979, the decision was made to calculate and present potential temperature rather than measured ambient temperature. Potential temperature 0 is defined as that temperature obtained by a parcel of air at temperature T and pressure P after adiabatic expansion or compression to 1000 mb, i.e.

$$= T\left(\frac{1000}{P}\right)^{R/Cp} \qquad (17)$$

where R/Cp = 0.286 for dry air.

The derivation and method of calculating potential temperature in the pibal program is described in Appendix I. It should be noted that in order to carry out this calculation, a measurement of the atmospheric pressure at ground level at the time of each release was required. For historical pibal releases with no pressure data, the Atmospheric Environment Service pressure measurements at Sudbury Airport were used after being corrected for the difference in elevation.

The decision to change to potential temperature was made because it provides a more easily interpreted indicator of atmospheric stability than does ambient temperature. This reduced the work involved in later analyses quite significantly.

3.1.3 Data Smoothing

The wind speed and direction profiles calculated using Thyer's method were reanalysed using a mathematical routine to smooth out random errors in the theodolite data. The smoothing algorithm was a modified version of a smoothing routine proposed by Thyer (7).

A description of the smoothing routine is given in several references (3,5) and the reader is referred to these for details. It was developed on the premise that a balloon's ascent is relatively smooth in all coordinate axes. This may not always be the case because of random turbulent fluctuations in the atmosphere but it is generally a reasonable assumption.

The method takes the calculated x, y and z coordinates of the balloon, finds an error bar associated with each coordinate at each 30 second interval during the flight and then calculates the smoothest

path through all of these error bars. The original x, y and z coordinates are then replaced by the new smoothed coordinates and the wind speed and direction profiles are recalculated.

3.1.4 Printing, Plotting and Storage

The smoothed wind speed, wind direction and potential or ambient temperature data for each release were printed, plotted and stored on the HP 9825 computer. Table 3 shows the final print-out of smoothed data (indicated under the title) after the potential temperature analysis was initiated. Again it indicates the Date, Time, Met Conditions, Plume conditions, Pressure and Humidity. It then tabulates the following:

(a) Time into balloon ascent (min.)

(b) Height (MSL) in metres

(c) Ambient Temperature (^{o}C)

(d) Potential Temperature (^{o}C)

(e) Potential temperature lapse rate (degrees C/m of height)

(f) Rise rate of balloon between readings (m/s)

(g) Wind speed (m/s) - smoothed

(h) Wind direction (degrees w/t true north) - smoothed

The vertical wind and temperature profiles were then plotted. Figure 6 shows the plot of the same data tabulated in Table 3. Before potential temperature was plotted routinely, both the ambient temperature and the dry adiabatic lapse rate (-0.98^{o}C/100m) curves were plotted.

Finally, the smoothed data shown in Table 3 were stored on disc. These discs are available both at the Air Resources Branch in Toronto

and the Northeastern Regional Offices in Sudbury. The pibal analysis program including Thyer's analysis and the smoothing routine is attached in Appendix 2.

The smoothed wind speed, wind direction and temperature profiles made up the data base from which the climatotogical analyses for the Sudbury area were done.

3.2 Solar Radiation

The chart records of solar flux were manually digitized into hourly averages. To insure the quality of the data several spot checks were carried out against planimeter-determined averages. The comparison was excellent. After digitization, the data were stored in the HP 9825 computer and printed in tabular form. Appendix 3 contains all of the hourly average solar flux data obtained in the program.

4. ANALYSIS AND RESULTS

The wind, temperature and solar radiation data bases were further analysed to determine climatological characteristics of the convective boundary layer. The analyses were aided by a knowledge of the characteristics of the convective boundary layer on a diurnal basis. These characteristics are presented in a report (1) of several intensive field studies carried out in Sudbury. They are described here briefly.

The mixed layer generally grows rapidly on sunny days from 1000 to 1300 hours local time. By mid-afternoon, the mixed layer height, or mixing height, reaches quasi-steady-state conditions and remains approximately constant until roughly one hour before sunset. At this time the mixed layer rapidly deteriorates as convection is no longer maintained.

At any time, the convective boundary layer is characterized by an isothermal potential temperature gradient capped by a strong inversion. The wind speed is generally constant throughout the layer but increases rapidly above it while wind direction is generally variable thoughout the layer and becomes approximately constant above it.

4.1 Mixed Layer Heights

4.1.1 Data Analysis

The diurnal characteristics of the mixed layer discussed in Kaimal et al (7) and Vet et al. (1) were used to produce statistical analysis of the the mixed layer height. It was a multi-step process, i.e.

(a) For the period from August, 1976 to September, 1979, all mid-day vertical profiles of wind speed, wind direction and temperature were recorded. Table 4 indicates the exact study period.

(b) A new series of computer plots was generated for the isolated data set. These plots consisted of vertical profiles of potential temperature only. For the individual months of May, June, July, August and September, the profiles were plotted in sequence from 1976 to 1979. The entire set of these plots is presented in Apendix 4.

(c) Each profile in Appendix 4was analysed for its mixed layer depth by looking for the height of the capping inversion. The analysis was based on the characteristics of the mixed layer described earlier namely, the mixed layer height is delineated by a strong capping inversion under which a roughly isothermal potential temperature gradient is present.

(d) When the aforementioned characteristics were not clearly discernible, other information was used to determine the mixing height. First, wind speed and wind direction profiles were examined for typical convective layer characteristics. These characteristics were sufficient for determining mixing heights for most of the releases. For those which were still unclear, additional information was used, e.g., solar flux, cloud cover, morning profiles, and plume behaviour observations.

(e) The mid-day mixed layer height for each release was placed in a computer data base. The maximum, minimum, and arithmetic mean mixing heights as well as the standard deviations, frequency distributions and coefficients of variation were calculated for each month by combining several years worth of data for the given month.

4.1.2 Results

The results of the mixing height analysis are presented in Table 5 and plotted in Figure 7. They are summarized as follows:

(a) The June, July and August mean mixing heights were roughly equivalent with magnitudes of 1084± 473, 1072± 394 and 1089± 311 m respectively. All heights are above ground level. For the three months combined, the mean mixing height was 1082± 403 m.

(b) May and September mean mixing heights were also roughtly equivalent with magnitudes of 916 and 908 m repsectively. These means were approximately 15% less then those for the other months.

(c) The maximum mixed layer height varied considerably from month to month. The greatest value occurred in June at 2330 m and the least value in September at 1470 m.

(d) The minimum mixed layer height also varied considerably from month to month with a maximum of 520 m in July and a minimum of 245 m in June. The minimum mixing heights correspond to days of low thick cloud cover.

(e) The coefficients of variation for the monthly mixing heights

indicate that more variability in the height occurred in May and June than the other months.

The frequency distributions of the mixing height data are shown in Figures 8 -15. They indicate that the overall data set is normally distributed and that roughly 90% of the measured mixing heights exceed the 381 m stack height (approximately 680 m MSL).

4.2 Mixed Layer Winds

The wind speed and wind direction data were combined with the mixing height data to produce an analysis of the mixed layer winds.

4.2.1 Data Analyses

Each mid-day wind and temperature profile on file in the meteorological data base was analysed for its mixed layer average wind speed and direction. This was done by converting the stored polar coordinates (wind velocity and angular direction) at each measurement interval to rectangular coordinates, calculating the weighted-average wind components (Equations 14(a) and 14(b)) up to the mixing height, then transforming back to polar coordinates.

$$V_x = \sum_{i=1}^{H} V_{xi} \cdot \Delta h_i \Big/ \sum \Delta h_i \qquad (14a)$$

$$V_y = \sum_{i=1}^{H} V_{yi} \cdot \Delta h_i \Big/ \sum \Delta h_i \qquad (14b)$$

where V_x = east-west wind component

V_y = north-south wind component

Δh_i = height intervals between theodolite readings

H = mixing height.

This analysis was done for all balloon releases in which the wind data extended to at least one half the mixed layer height. Such a criterion introduces some bias to the results because of wind direction changes with height within the mixed layer. However, it was felt that the final statistical analysis of the results was relatively insensitive to the inherent errors.

4.2.2 Results

Mixed layer wind roses were constructed for individual months using the available data from 1976 to 1979 (Figures 16 - 22). They illustrate a very strong tendency for southwesterly component winds and a general predominance of winds in the south to west quadrant with a slightly smaller northerly bias. Mixed layer wind speed frequency histograms were constructed (Figures 23 -29). The monthly and seasonal plots illustrate a predominant wind speed in the 4 to 6 m/s category.

The apparent difference in wind characteristics from different quadrants led to a more detailed analysis. The data were separated into the following categories:

(a) all data

(b) winds associated with a westerly component, i.e., N to W to S

(c) winds associated with an easterly component, i.e., N to E to S

Table 6 summarizes the mixed layer wind speed data from category (a) all winds. The monthly mean wind speeds varied from 5.0 m/s in September to 6.7 m/s in June with a May to September average of 5.9 m/s.

After separation into directional categories (b) and (c) (Tables 7 and 8 respectively), the wind speeds show a dramatic change. The mean wind speeds from May to September were 6.4 $\pm$ 3.0 m/sec. for the westerly component winds and 3.8 $\pm$ 2.2 m/s for the easterly component winds corresponding to a 1.68 times increase in average wind speed. In addition, the frequency of westerly component winds was roughly 4 times that of easterly component winds.

The dramatic directional dependence of mixed layer winds suggested that mixed layer heights may also be directionally dependent. The mixing height data were therefore separated into two categories, namely, those having westerly component winds and those having easterly component winds, and were further analysed. The resultant monthly and seasonal means for the two data sets are shown in Figure 30. They indicate that the arithmetic means and standard deviations for the westerly and easterly sets of the entire data set were 1101 $\pm$ 404 m and 981 $\pm$ 337 m/s respectively. The data were not tested for significant statistical difference.

Great care must be taken in assessing the mixed layer wind analyses. Unlike mid-day mixing heights (which are relatively steady-state and representative of entire afternoons), the wind data are highly variable in time. The pilot balloon measurements, being essentially instantaneous, do not provide time-averaged data although they are analysed here as representative of time averages. In addition, the number of data points in some months and for some components is very small. Hence, the statistical data given in this section should be considered as indicators of tendencies in mixed layer wind characteristics rather than as climatological data.

4.3 Potential Temperature Lapse Rates

The change in potential temperature with height (i.e. lapse rate) has a characteristic behaviour within and above the mixed layer. Within the layer the potential temperature is roughly constant and invariant with height corresponding to a zero lapse rate and a neutral atmosphere. The capping inversion at the top of layer is usually a highly stable narrow layer with a sharp positive potential temperature gradient. Above this inversion is a thick stable layer with a smaller positive lapse rate.

Investigators (8) have shown that the lapse rate within the layer above the capping inversion is a controlling parameter in the growth of the mixed layer because it represents the buoyancy structure of the atmospheric layer which convective turbulence must penetrate and erode in order for the mixed layer to grow.

An analysis of the potential temperature data was therefore carried out to determine the characteristic lapse rate of this upper layer.

4.3.1 Data Analysis

Each mid-afternoon potential temperature profile in the meteorological data base was manually inspected. The layer above the CBL capping inversion was noted and the average lapse rate within the layer was measured. Only those profiles with a minimum vertical extent of 300 to 500 m in the upper layer were analysed. Statistical analyses were then carried out on the data.

4.3.2 Results

The maximum, minimum, and mean potential temperature lapse rates are shown in Table 9. The monthly means range from 2.8 ± 1.2 $^{o}C/Km$ in September to 3.8 ± 1.6 $^{o}C/Km$ in May with a seasonal mean of 3.3 ± 1.7 $^{o}C/Km$.

The frequency distributions of the lapse rate data are shown in Figures 31 to 37. The probability plot shown in Figure 38 indicates that the overall distribution of the data is normal.

4.4 Solar Flux

The importance of solar radiation to the development and maintenance of the convective boundary layer has been noted by

many investigators (8,9). The measurement and statistical analysis of these data was therefore considered of importance to the objectives of the Sudbury Environmental Study.

4.4.1 Data Analysis

The hourly-averaged values of incoming solar radiation were analysed to produce the following:

(a) Monthly maximum, minimum and mean values of solar flux for each hour of the day during each month. Where more than one year's data was available for a given month, all years were combined. Special attention is again given to the months of May through September because of the convective activity during those months. Data from the other months has been included for completeness. All days were included in this analysis regardless of the weather conditions.

(b) The monthly mean solar flux values for each hour were scanned to pick out the peak value. This value was called the mid-day monthly mean and was plotted against the mid-day absolute maximum value. Both of these values generally occurred in the 1200 to 1400 hour time period.

(c) The solar flux data between May and September were then analysed in more detail by separating out those days during

which convective activity was known to occur. This eliminated the effect of overcast and rainy days on the data and provided data complementary to the mixing height data.

4.4.2 Results

The monthly maximum, minimum and mean values of solar radiation for each hour of all days are given in Appendix 5 and Figures 39 to 50. The mid-day mean values plotted against mid-day maximum values appear in Figure 51 and the average data for the May to September period are given in Table 10.

The maximum hourly value of solar flux reached throughout the entire study period was 1123 W/m^2. The monthly mean values at mid-day, however, were 200 to 500 W/m^2 less than the respective monthly maximum values. Mean mid-day values ranged between 600 to 800 W/m^2 typically. The diurnal cycle of the solar radiation was sinusoidal as expected.

Analyses of the convective solar flux data are presented in monthly averages for each hour of the day in Appendix 5. In Figures 52 to 58 both the convective data and the all-weather data are plotted together. Figure 59 is a plot of the convective versus all-weather mid-day mean solar fluxes for each month. The average convective data for May through September are given in Table 11.

The data indicate that, for the period studied, the mean mid-day solar flux for the convective days ranged from 650 W/m^2 to 850 W/m^2. These values are 50 to 250 W/m^2 greater than the mid-day means for all-weather conditions.

5. DISCUSSION

The results of the mixed layer height, mixed layer wind, lapse rate and solar flux analyses must be considered with some care. Because of the short term nature of the program, the number of data points in each analysis is quite limited. The results reflect only those years during which the measurements were taken and extrapolation beyond those years should be done with caution.

The mixed layer height and mixed layer wind analyses are very important in assessing the fate of pollutants emitted in the Sudbury area. The consistent mid-day average mixing heights of roughly 1000 m above ground level for the months of May through September indicate that the effectiveness of a tall stack for eliminating ground level concentrations is minimal during convective periods. This is not the case however, during the night and during winter months when nocturnal inversions (shown in the early morning minisonde data) are generally below plume level and tend to trap the plume aloft-preventing it from impinging at ground level. Therefore, under these conditions, dry deposition is expected to be minimal.

The strong bias for westerly component mixed layer winds suggests that the dry deposition field for locally emitted pollutants should also be biased. Based on the data analysed here, increased dry deposition would be expected in the northeasterly, easterly and southerly directions due to increased wind direction frequencies alone.

The indications (based on a small data base) of stronger wind speeds with westerly component winds also has a major impact on local air quality and dry deposition. It suggests that, on average, ground level concentrations and dry deposition, (from meteorological

considerations alone), should be lower near the stack for westerly component winds than for easterly component winds.

Finally, the convective boundary layer is a very significant meteorological characteristic of the Sudbury area. Its existence and structure have been well-established and a significant meteorological data base is available for assessing its impact on the fate of local emissions.

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Sudbury Environmental Study

11/ 7/1978 520

Baseline 3 Bearing 237.30 Length 343.96

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PRESSURE 937.7 REL. HUMIDITY 0%

Time (min)	Azimuth 1 (degrees)	Elevation 1 (degrees)	Azimuth 2 (degrees)	Elevation 2 (degrees)	Temp. (degrees C)	Mid-Point Temp. (degrees C)
0.0	156.91	14.51	179.80	359.74	9.7	
0.5	259.33	32.69	204.36	14.09	9.4	9.5
1.0	253.22	24.59	229.17	18.29	10.4	9.6
1.5	255.92	21.90	241.47	19.31	10.2	10.3
2.0	263.22	21.07	248.93	19.69	9.7	10.0
2.5	259.53	20.63	253.73	19.80	9.1	9.4
3.0	270.44	20.62	256.64	20.02	8.8	9.0
3.5	270.79	20.32	258.58	20.35	9.1	9.5
4.0	271.80	21.01	260.73	20.73	7.6	7.9
4.5	272.83	21.11	262.81	20.90	7.0	7.3
5.0	273.25	21.23	264.08	21.17	6.2	6.6
5.5	273.40	21.50	264.92	21.33	5.8	6.0
6.0	273.40	21.66	265.51	21.59	5.0	5.4
6.5	273.62	21.73	266.31	21.71	4.1	4.6
7.0	274.20	21.80	267.39	21.80	3.2	3.7
7.5	274.99	21.68	268.68	21.67	2.8	3.0
8.0	275.57	21.49	269.70	21.49	2.0	2.4
8.5	275.08	21.30	270.59	21.34	1.2	1.7
9.0	275.52	21.11	271.41	21.20	0.6	1.0
9.5	277.00	20.89	272.18	20.97	-0.1	0.2
10.0	277.50	20.56	272.98	20.72	-0.8	-0.5
10.5	277.98	20.40	273.63	20.49	-1.0	-0.9
11.0	278.63	20.19	274.53	20.28	-1.7	-1.4
11.5	279.45	19.99	275.59	20.07	-2.0	-1.9
12.0	280.04	19.75	276.38	19.82	-2.7	-2.4
12.5	280.68	19.46	277.21	19.55	-3.1	-2.9
13.0	281.49	19.20	278.16	19.32	-3.6	-3.4
13.5	282.25	19.00	279.11	19.19	-3.6	-3.6
14.0	282.90	18.81	279.90	18.97	-3.7	-3.6
14.5	283.46	18.55	280.59	18.70	-3.0	-3.2
15.0	999.00	999.00	999.00	999.00	-3.0	-3.0
15.5					-3.4	-3.2
16.0					-4.0	-3.7

Table 1: Raw Pibal-Minisonde Data

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Table 2

Analyzed Pibal-Minisonde Data

Baseline 3 Bearing 237.30 Length 343.35

Time (min)	X (metres)	Y (metres)	Height (metres)	Height (metres)	Temp. (Degrees C)	Rise Rate (metres/sec)	Vxy (metres/sec)	Wind Direction (deg. rel. true north)	Tau
0	1.56	-3.56	1.04	237.34	9.7				
			54.34	310.34	9.5				
0.5	-163.53	-31.46	103.54	351.54	9.4	3.5	5.7	313.3	5.3
			158.35	414.35	9.5				
1.0	-459.33	-54.33	203.35	451.35	10.4	3.3	5.7	322.3	7.2
			250.79	505.79	10.3				
1.5	-723.25	-51.35	293.53	540.53	10.2	2.1	5.1	327.3	-0.3
			334.76	590.76	10.0				
2.0	-974.07	-30.23	375.99	631.99	9.7	2.7	5.2	332.3	-0.5
			416.20	672.20	9.4				
2.5	-1203.39	-8.35	456.42	712.42	9.1	2.7	7.9	332.5	-0.1
			493.28	749.28	9.0				
3.0	-1403.24	13.31	533.15	785.15	8.3	2.5	5.7	332.9	-0.2
			568.18	824.18	8.5				
3.5	-1593.92	21.33	606.21	852.21	8.1	2.5	5.2	333.7	-0.3
			643.08	889.08	7.9				
4.0	-1767.27	55.51	679.95	915.95	7.6	2.5	5.9	331.3	-0.5
			718.53	971.53	7.3				
4.5	-1953.34	95.33	757.12	1013.12	7.0	2.5	5.5	333.5	1.0
			797.01	1053.01	6.6				
5.0	-2143.39	121.72	836.93	1092.93	6.2	2.7	5.2	335.3	-0.3
			875.23	1131.23	6.0				
5.5	-2313.75	137.75	913.57	1169.57	5.8	2.6	5.9	332.5	1.5
			953.02	1209.02	5.4				
6.0	-2493.56	143.15	992.43	1248.43	5.0	2.6	5.3	333.7	-0.2
			1034.34	1290.34	4.6				
6.5	-2692.23	173.34	1075.21	1332.21	4.1	2.3	5.7	333.7	-0.4
			1117.38	1373.38	3.7				
7.0	-2339.31	212.23	1159.55	1415.55	3.2	2.3	5.7	333.3	-0.2
			1201.17	1457.17	3.0				
7.5	-3115.59	272.11	1242.79	1498.79	2.8	2.3	7.3	332.1	1.3
			1282.64	1538.64	2.4				
8.0	-3317.14	326.33	1322.13	1578.13	2.0	2.7	7.9	333.5	1.5
			1361.61	1617.61	1.7				
8.5	-3571.73	383.75	1401.72	1656.72	1.2	2.5	7.3	333.7	1.3
			1445.74	1701.74	1.0				
9.0	-3835.30	433.35	1491.75	1746.75	0.5	3.0	8.9	333.3	-0.1
			1525.76	1781.76	0.2				
9.5	-4063.07	493.53	1563.77	1815.77	-0.1	2.3	7.3	332.3	0.1
			1601.34	1857.34	-0.5				
10.0	-4321.31	553.93	1641.91	1897.91	-0.8	2.7	8.0	332.1	0.1
			1671.91	1927.91	-0.9				
10.5	-4531.72	631.54	1701.91	1957.91	-1.0	2.0	7.1	333.7	0.2
			1742.95	1998.95	-1.4				
11.0	-4800.27	723.53	1783.93	2039.93	-1.7	2.7	9.1	337.3	0.3
			1815.34	2071.34	-1.9				
11.5	-5017.53	785.95	1847.53	2103.53	-2.0	2.1	8.1	353.1	0.5
			1883.63	2139.63	-2.1				

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Table 2
(Continued)

Baseline 3 Bearing 237.30 Length 343.96

Time (min)	X (metres)	Y (metres)	Height (metres)	Height (MSL) (metres)	Temp. (degrees C)	Rise Rate (metres/sec)	Vxy (metres/sec)	Wind Direction (deg. rel. true north)	Tau
12.0	-5274.77	933.77	1913.67	2175.67	-2.7	2.4	9.2	348.3	0.7
			1954.79	2216.79	-2.9				
12.5	-5542.54	1045.15	1993.91	2255.91	-3.1	2.3	9.7	349.9	0.5
			2014.99	2277.99	-3.4				
13.0	-5745.09	1157.93	2033.07	2295.07	-3.5	1.7	7.9	351.4	0.3
			2037.68	2303.53	-3.5				
13.5	-6054.50	1314.73	2135.23	2391.23	-3.5	3.2	11.4	352.3	-0.3
			2170.24	2426.24	-3.6				
14.0	-6310.69	1445.34	2235.19	2151.19	-3.7	2.3	9.5	351.3	0.0
			2235.41	2491.41	-3.2				
14.5	-6553.31	1572.02	2255.52	2521.52	-3.0	2.0	9.5	353.5	0.1
			2306.12	2562.12	-3.0				
15.0			2315.52	2502.52	-3.0				
			2387.12	2643.12	-3.2				
15.5			2427.62	2533.52	-3.4				
			2468.12	2724.12	-3.7				
16.0			2533.62	2751.62	-4.0				

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Sudbury Environmental Study
Smoothed Data

11/ 7/1978 520

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PLUME DATA: coning to S

PRESSURE 937.7 REL. HUMIDITY 0%

Time (min)	Height (MSL) (metres)	Temp (deg C)	Potential Temp (deg C)	P.T. Lapse Rate (deg C/m)	Rise Rate m/s	Vav (metres/sec)	Wind Direction (deg rel. true north)
0.0	257.04	9.7	13.7				
	307.70	9.5	11.0	0.00533			
0.5	358.35	9.4	11.4	0.00783	3.4	5.9	318.3
	406.13	9.6	12.1	0.01435			
1.0	453.90	10.4	13.3	0.02675	3.2	3.4	322.7
	501.68	10.3	13.7	0.00775			
1.5	549.45	10.2	14.1	0.00776	3.2	3.1	327.7
	590.13	10.0	14.3	0.00431			
2.0	630.82	9.7	14.4	0.00242	2.7	3.2	332.3
	671.51	9.4	14.5	0.00242			
2.5	712.19	9.1	14.6	0.00242	2.7	7.9	332.5
	749.59	9.0	14.8	0.00722			
3.0	786.98	8.8	15.0	0.00450	2.5	6.7	332.9
	824.37	8.5	15.1	0.00177			
3.5	861.77	8.1	15.0	-0.00097	2.5	5.2	333.7
	899.64	7.9	15.2	0.00459			
4.0	937.51	7.6	15.3	0.00138	2.5	5.9	339.4
	975.39	7.3	15.4	0.00138			
4.5	1013.26	7.0	15.4	0.00139	2.5	6.5	338.4
	1052.46	6.6	15.4	-0.00046			
5.0	1091.67	6.2	15.4	-0.00046	2.6	6.2	335.3
	1130.87	6.0	15.6	0.00431			
5.5	1170.07	5.8	15.3	0.00431	2.6	5.9	332.5
	1209.85	5.4	15.8	-0.00031			
6.0	1249.63	5.0	15.7	-0.00031	2.7	5.9	333.7
	1291.00	4.6	15.8	0.00039			
6.5	1332.36	4.1	15.7	-0.00243	2.8	6.6	333.7
	1373.73	3.7	15.7	0.00039			
7.0	1415.09	3.2	15.6	-0.00243	2.8	6.8	339.2
	1456.46	3.0	15.8	0.00514			
7.5	1497.83	2.8	16.0	0.00515	2.8	7.8	342.0
	1536.14	2.4	16.0	-0.00018			
8.0	1574.46	2.0	16.0	-0.00018	2.7	7.8	340.7
	1616.77	1.7	16.1	0.00243			
8.5	1659.09	1.2	16.0	-0.00279	2.7	7.8	340.7
	1702.36	1.0	16.2	0.00541			
9.0	1745.63	0.6	16.2	0.00054	2.9	8.8	339.8
	1782.54	0.2	16.2	-0.00115			
9.5	1819.45	-0.1	16.2	0.00172	2.5	7.8	342.2
	1856.35	-0.5	16.2	-0.00115			
10.0	1893.26	-0.8	16.3	0.00173	2.5	9.0	342.5
	1926.67	-0.9	16.5	0.00719			
10.5	1960.07	-1.0	16.7	0.00720	2.2	7.5	343.6
	1998.16	-1.4	16.7	-0.00030			
11.0	2036.25	-1.7	16.8	0.00200	2.6	9.4	347.5
	2071.20	-1.9	16.9	0.00431			
11.5	2106.15	-2.3	17.2	0.00733	2.3	3.2	353.3
	2141.10	-2.4	17.1	-0.00131			
12.0	2176.06	-2.7	17.2	0.00125	2.3	9.2	343.3
	2207.29	-2.9	17.3	0.00350			
12.5	2238.53	-3.1	17.4	0.00350	2.1	9.5	350.4
	2269.77	-3.4	17.4	0.00016			
13.0	2301.01	-3.6	17.5	0.00351	2.1	3.1	357.3
	2343.50	-3.6	17.1	-0.01061			
13.5	2385.99	-3.6	16.6	-0.01049	2.8	11.3	353.0
	2423.55	-3.6	16.2	-0.01043			
14.0	2461.11	-3.7	16.5	0.00752	2.5	9.6	354.2
	2491.37	-3.2	17.4	0.02326			
14.5	2521.63	-3.0	17.9	0.01752	2.0	9.6	353.5
	2562.38	-3.0	17.5	-0.01050			
15.0	2603.13	-3.0	17.0	-0.01049	2.7	1.4	337.7
	2643.88	-3.2	17.3	0.00521			
15.5	2684.63	-3.4	17.5	0.00522	2.7	0.0	0.0
	2725.38	-3.7	17.5	0.00253			
16.0	2766.13	-4.0	17.7	0.00253	2.7	0.0	0.0

TABLE 3

Smoothed Pibal-Minisonde Data

TABLE 4

Mixing Height Analysis Period

May	-	1977	1978	1979
June	-	1977	1978	1979
July	-	1977	1978	1979
August	1976	1977	1978	1979
September	1976	1977	1978	1979

TABLE 5

Mid-day Mixing Height Summary

Month(s)	Mean AGL(metres)	Maximum AGL(metres)	Minimum AGL(metres)	S. Dev. (metres)	C.V.	N
May	916	1712	366	417	0.46	25
June	1084	2328	245	473	0.44	43
July	1072	1985	519	394	0.37	32
August	1089	1661	326	311	0.29	31
September	1467	1467	908	297	0.33	13
May - Sept.	908	2328	1037	402	0.39	144
June - Aug.	1082	2328	1082	403	0.37	106

TABLE 6

Mixed Layer Wind Speed Summary
(m/s)

Month(s)	Maximum	Minimum	Mean	S.Dev.	N
May	10.6	2.0	6.0	2.4	19
June	16.3	1.8	6.7	3.4	38
July	10.9	0.6	5.1	2.5	30
August	13.0	0.8	5.9	3.4	26
September	9.4	1.6	5.0	2.6	9
May - Sept.	16.3	0.6	5.9	3.0	122
Jun - Aug.	16.3	0.6	6.0	3.2	94

TABLE 7

Mixed Layer Wind Speed Summary
(West Component)
(m/s)

Month(s)	Maximum	Minimum	Mean	S.Dev.	N.
May	10.6	2.4	6.4	2.5	13
June	16.3	1.8	7.3	3.2	32
July	10.9	2.2	5.7	2.3	24
August	13.0	0.8	6.4	3.5	22
September	9.4	1.6	4.7	2.7	6
May - Sept.	16.3	0.8	6.4	3.0	97
Jun - Aug.	16.3	0.8	6.5	3.1	78

TABLE 8

Mixed Layer Wind Summary
(East Component)
(m/s)

Month(s)	Maximum	Minimum	Mean	S.Dev.	N
May	7.6	2.0	5.1	1.9	6
June	8.7	1.8	3.4	2.7	6
July	4.9	0.6	2.6	2.7	6
August	3.5	2.0	3.1	0.8	4
September	8.7	4.1	5.6	2.7	3
May - Sept.	8.7	0.6	3.8	2.2	25
June - Aug.	8.7	0.6	3.0	1.8	16

TABLE 9

Potential Temperature
Lapse Rate Summary
(^{o}C/Km)

Month(s)	Minimum	Maximum	Mean	S.D.	N
May	1.0	6.0	3.8	1.6	10
June	0.3	7.0	3.5	1.9	40
July	1.0	6.5	3.5	1.6	21
August	0.5	9.0	3.0	1.8	20
September	1.0	4.0	2.8	1.2	10
May - Sept.	0.3	9.0	3.3	1.7	101
June - Aug.	0.3	9.0	3.3	1.8	81

TABLE 10

Ministry of the Environment
Sudbury Environmental Study

Solar Flux Analysis:

Months(s)		
	May	1977
	May	1979
	June	1977
	June	1978
	June	1979
	July	1977
	July	1978
	July	1979
	August	1977
	August	1978
	August	1979
	September	1978

Solar Flux (Watts/Sq.M.)

Hour	Maximum	Minimum	Average	Standard Deviation	# of Data Points
1-4	49 *	0	0	3	350
4-5	49	0	1	4	336
5-6	91	0	3	8	336
6-7	164	0	40	39	327
7-8	346	0	133	95	327
8-9	545	0	259	149	333
9-10	856	0	395	198	336
10-11	846	23	511	237	337
11-12	945	33	587	264	340
12-13	1123	33	637	282	339
13-14	1010	16	651	281	338
14-15	1006	25	612	270	341
15-16	903	8	546	250	341
16-17	807	16	456	214	340
17-18	771	8	348	177	340
18-19	598	0	222	129	339
19-20	553	0	107	81	340
20-21	328	0	29	36	339
21-22	150	0	2	9	340
22-23	0	0	0	0	367
23-24	0	0	0	0	367

* Spurious reading

TABLE 11

Ministry of the Environment

Sudbury Environmental Study

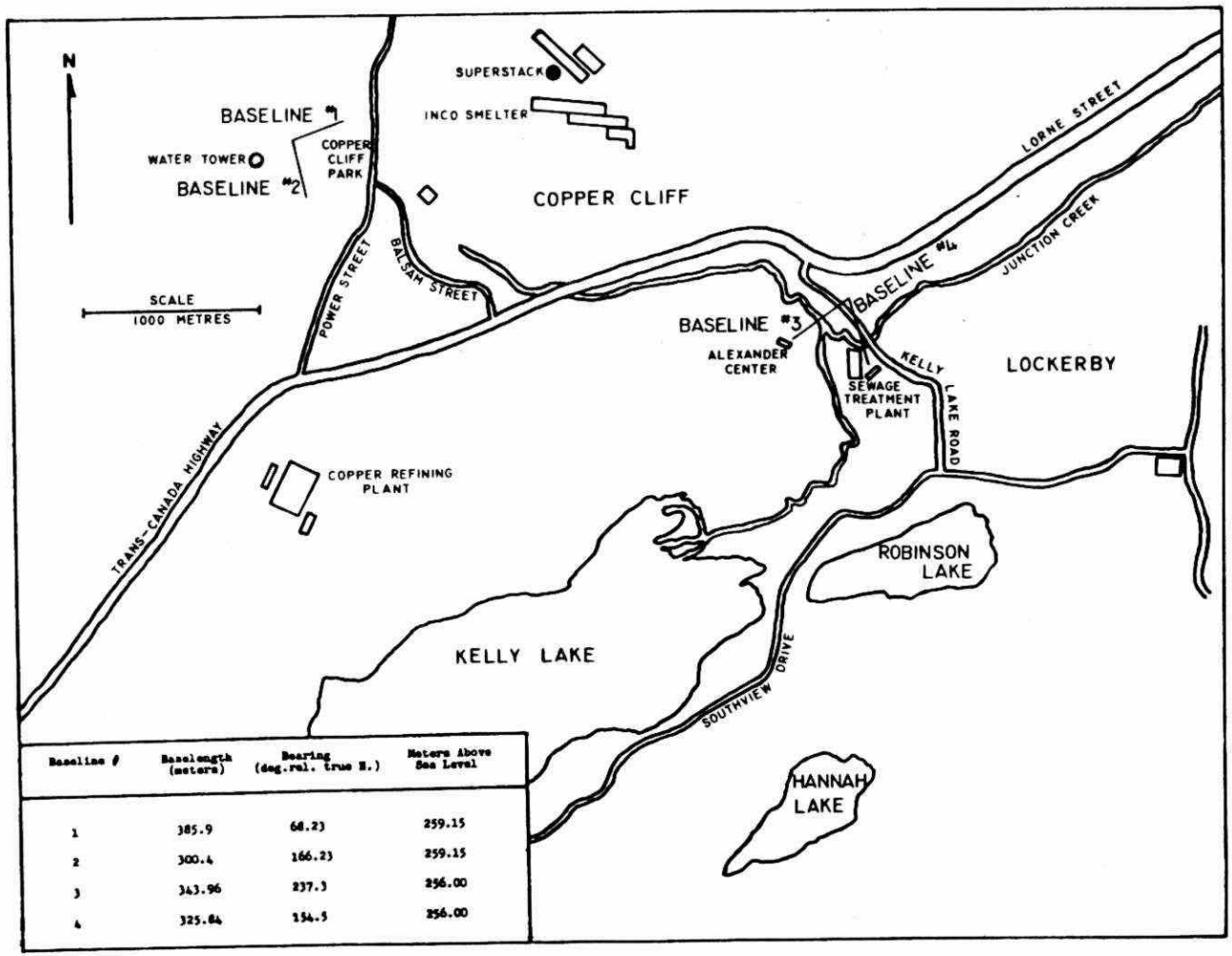
Solar Flux Analysis:

Month(s)		
	May	1977
	May	1979
	June	1977
	June	1978
	June	1979
	July	1977
	July	1978
	July	1979
	August	1977
	August	1978
	September	1978

Solar Flux (Watts/Sq.M.)

Hour	Maximum	Minimum	Average	Standard Deviation	#of Data Points
1-4	8 *	0	0	1	117
4-5	35	0	1	3	112
5-6	91	0	4	9	111
6-7	160	0	54	32	109
7-8	328	0	172	76	110
8-9	543	21	317	116	112
9-10	856	29	475	161	114
10-11	821	37	602	195	114
11-12	926	41	700	215	116
12-13	1959	33	751	215	115
13-14	1010	78	772	226	114
14-15	987	97	725	214	116
15-16	889	8	626	191	116
16-17	762	79	501	137	117
17-18	663	16	386	119	117
18-19	453	25	245	80	116
19-20	256	0	117	55	117
20-21	98	0	33	21	117
21-22	7	0	2	1	117
22-23	0	0	0	0	120
23-24	0	0	0	0	120

* Spurious reading



Baseline #	Baselength (meters)	Bearing (deg.rel. true N.)	Meters Above Sea Level
1	385.9	68.23	259.15
2	300.4	166.23	259.15
3	343.96	237.3	256.00
4	325.84	154.5	256.00

Figure 1: Theodolite Baseline Locations

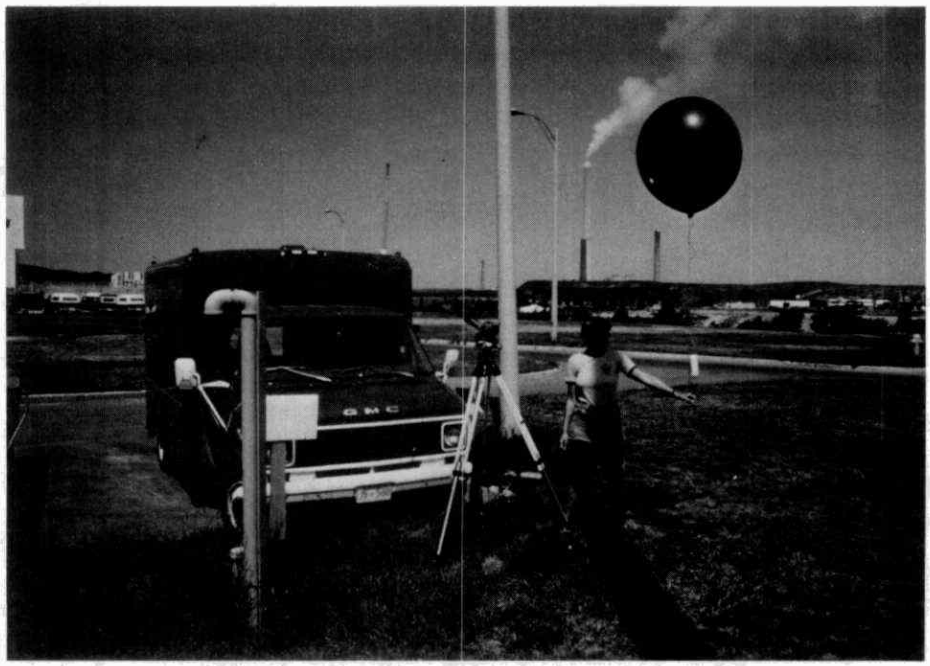


Figure 2: Meteorological Program Instrumentation. The pilot balloon, minisonde and theodolite are visible in the foreground, the INCO superstack in the background.

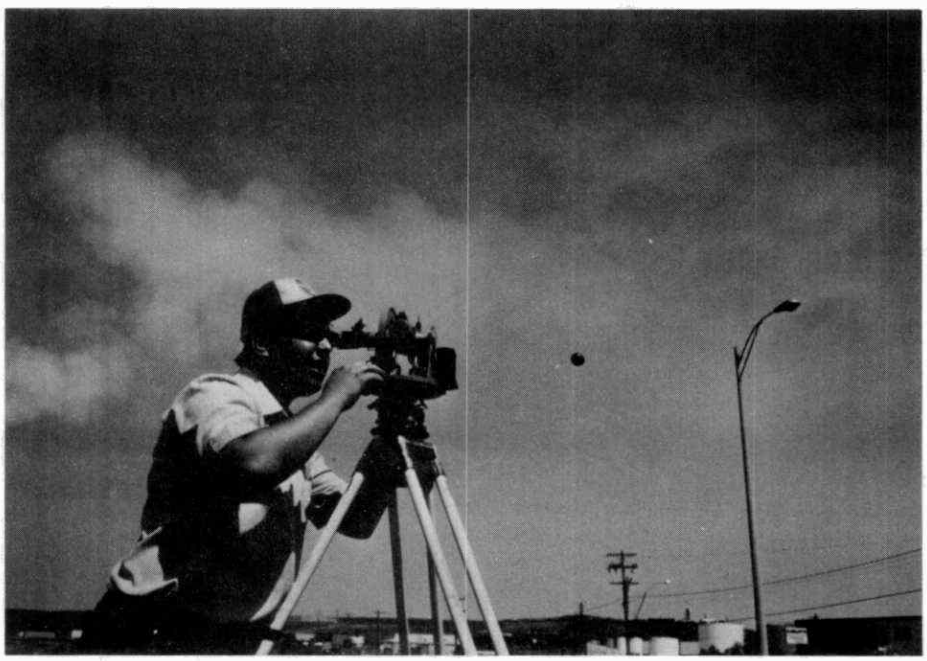


Figure 3: Meteorological Program Instrumentation. A Warren-Knight Theodolite being used to follow the pibal-minisonde.

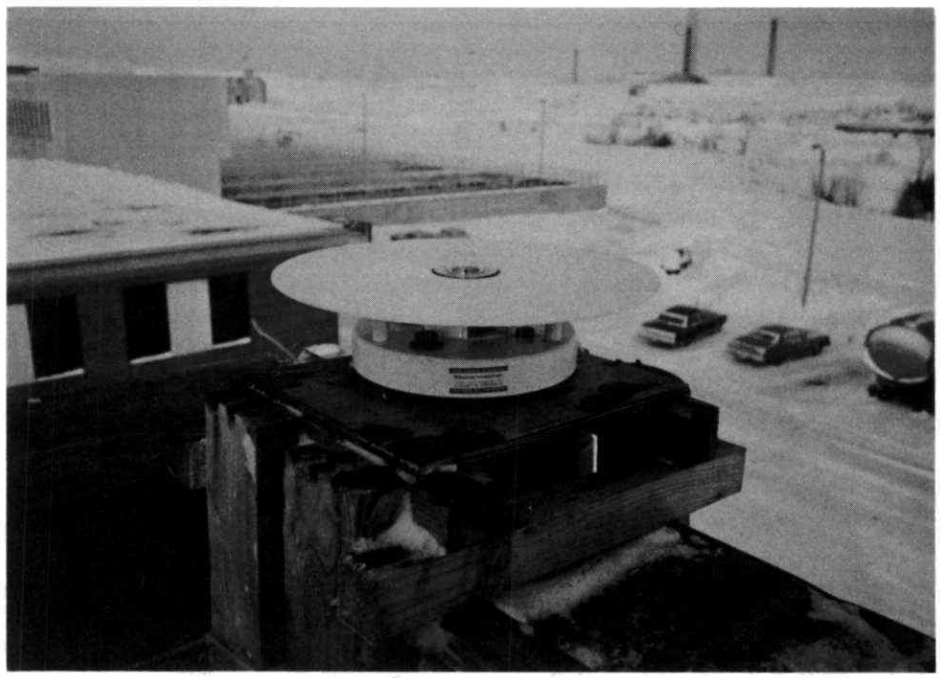


Figure 4: Meteorological Program Instrumentation -- The Kipp and Zonen Solarimeter

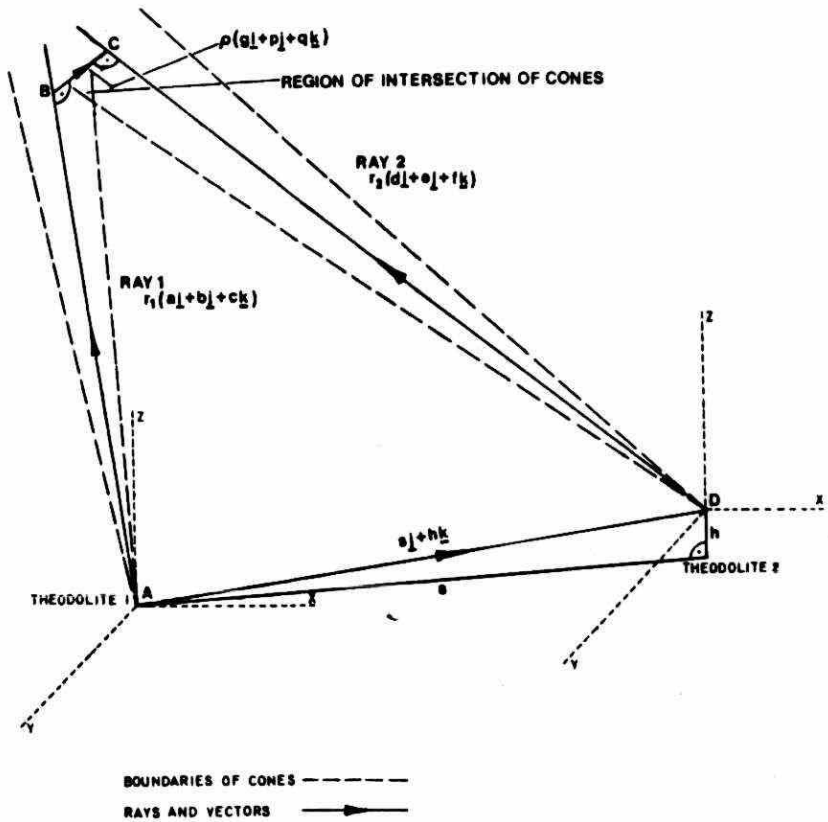


Figure 5: Theodolite - Balloon Geometry for Thyer's Analysis (From Thyer(2))

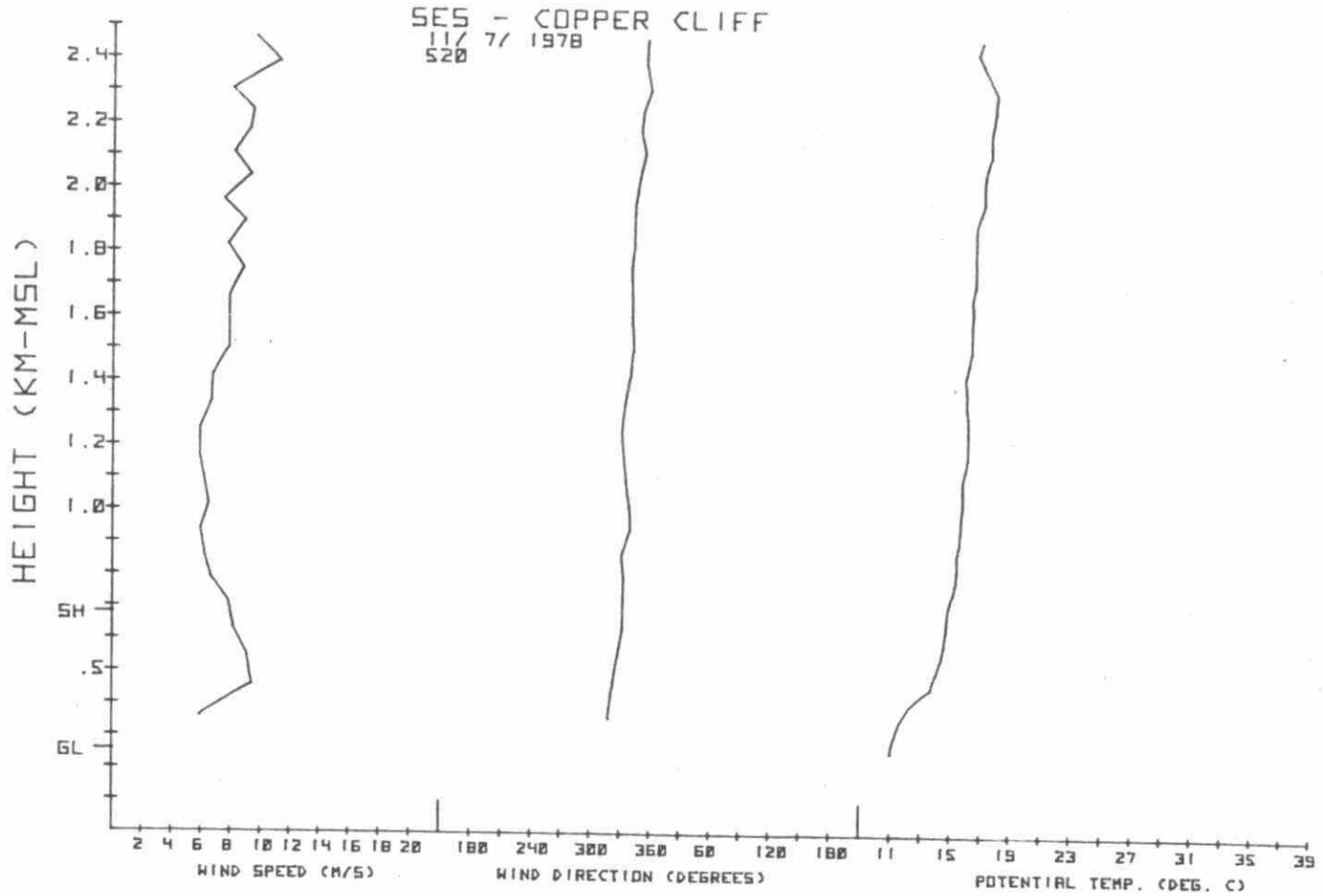


Figure 6: Vertical Profile of Wind Speed, Wind Direction and Potential Temperature.

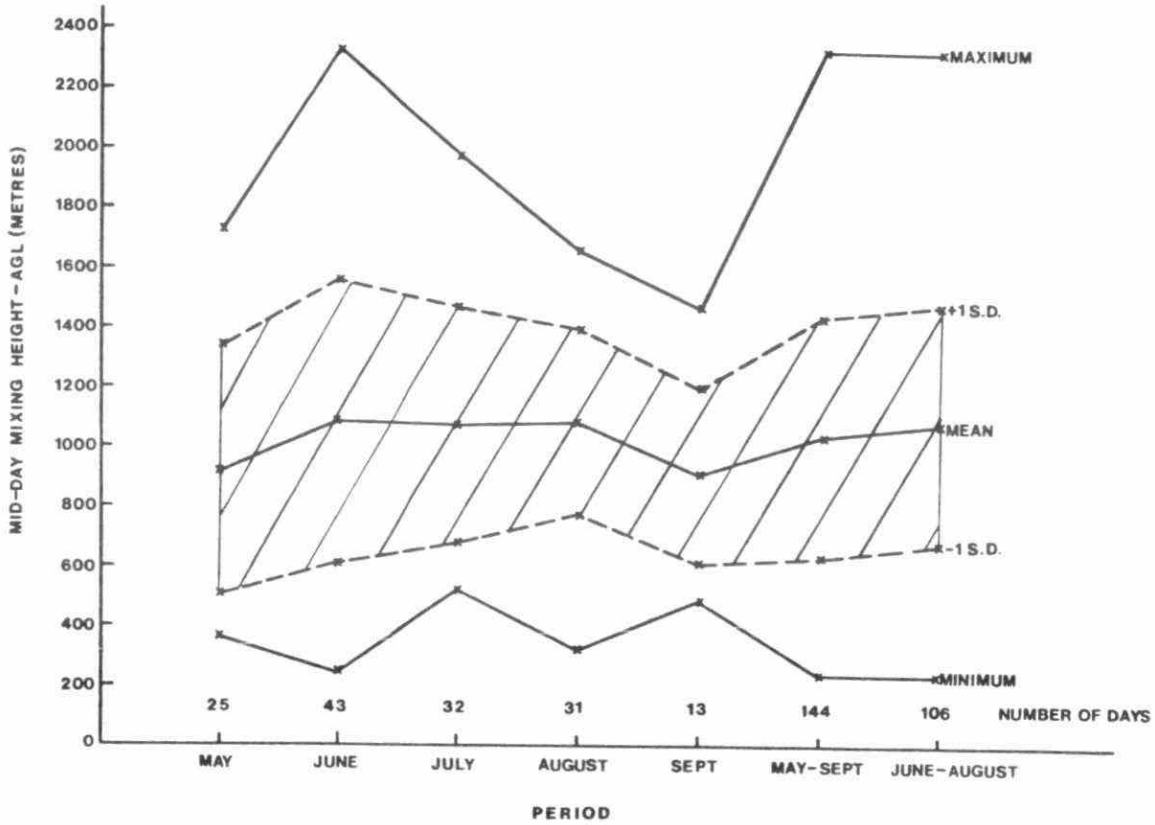


Figure 7: Mid-day Mixing Height Summary

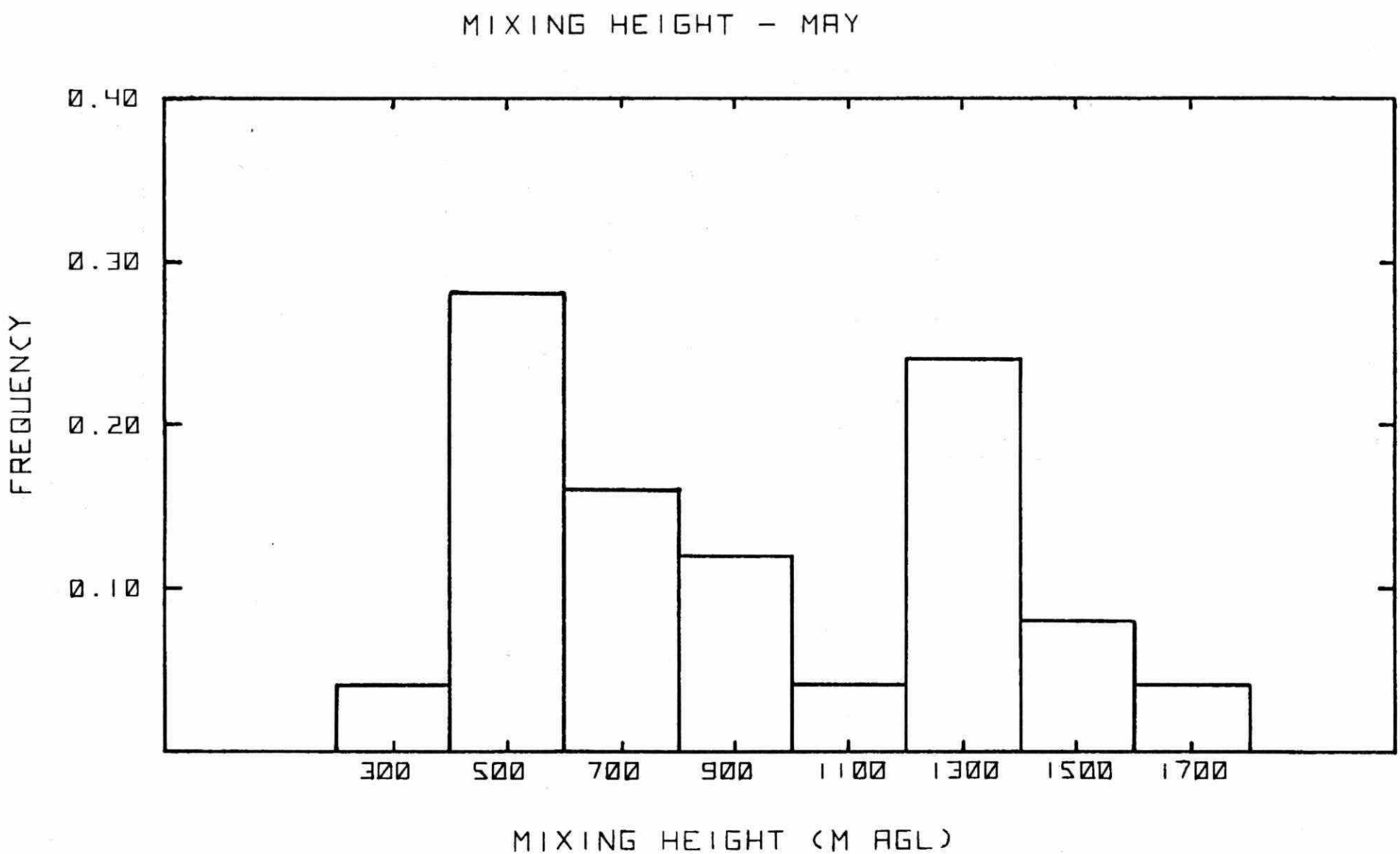


Figure 8: Mixing Height Frequency Distribution - May

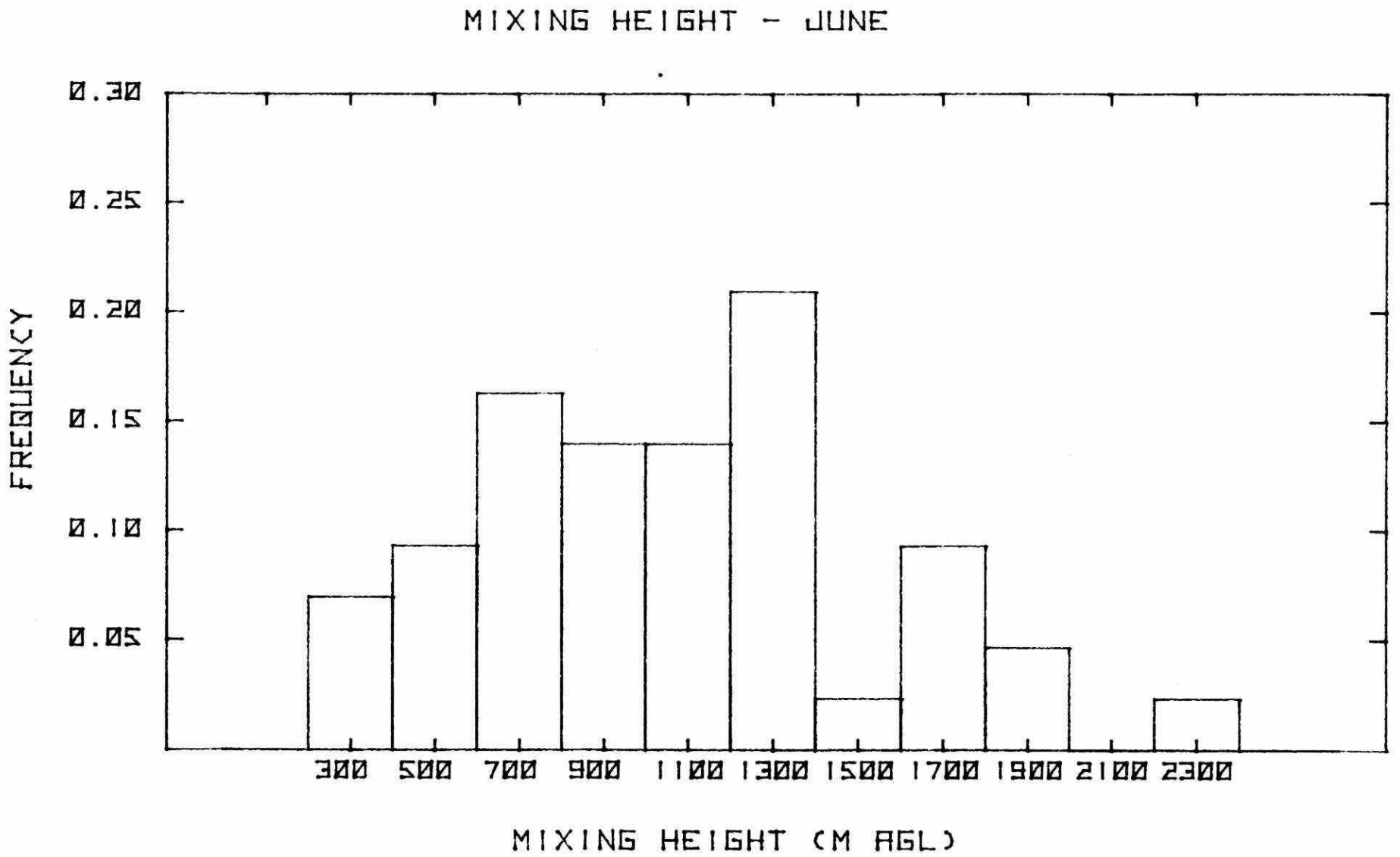


Figure 9: Mixing Height Frequency Distribution - June

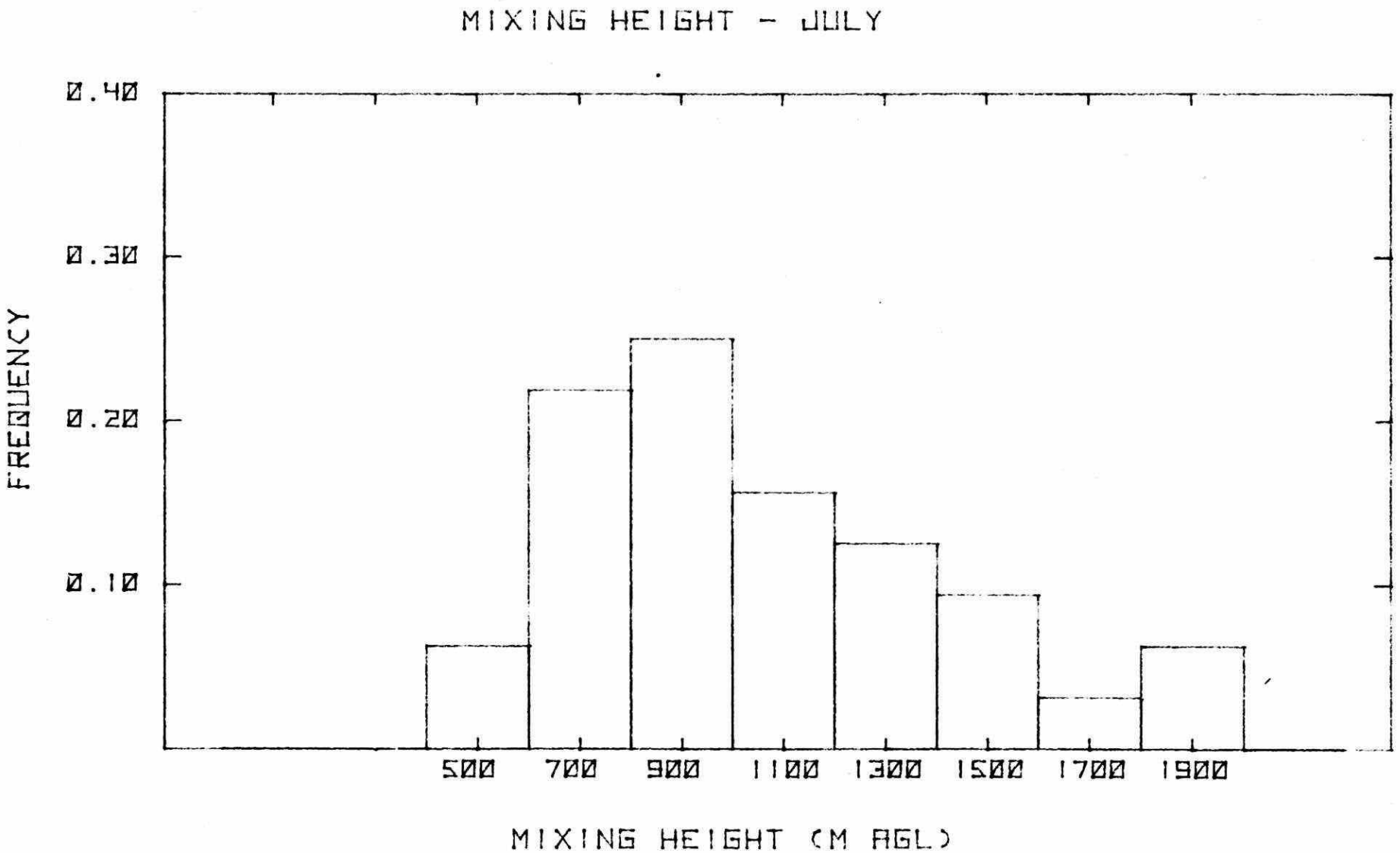


Figure 10: Mixing Height Frequency Distribution - July

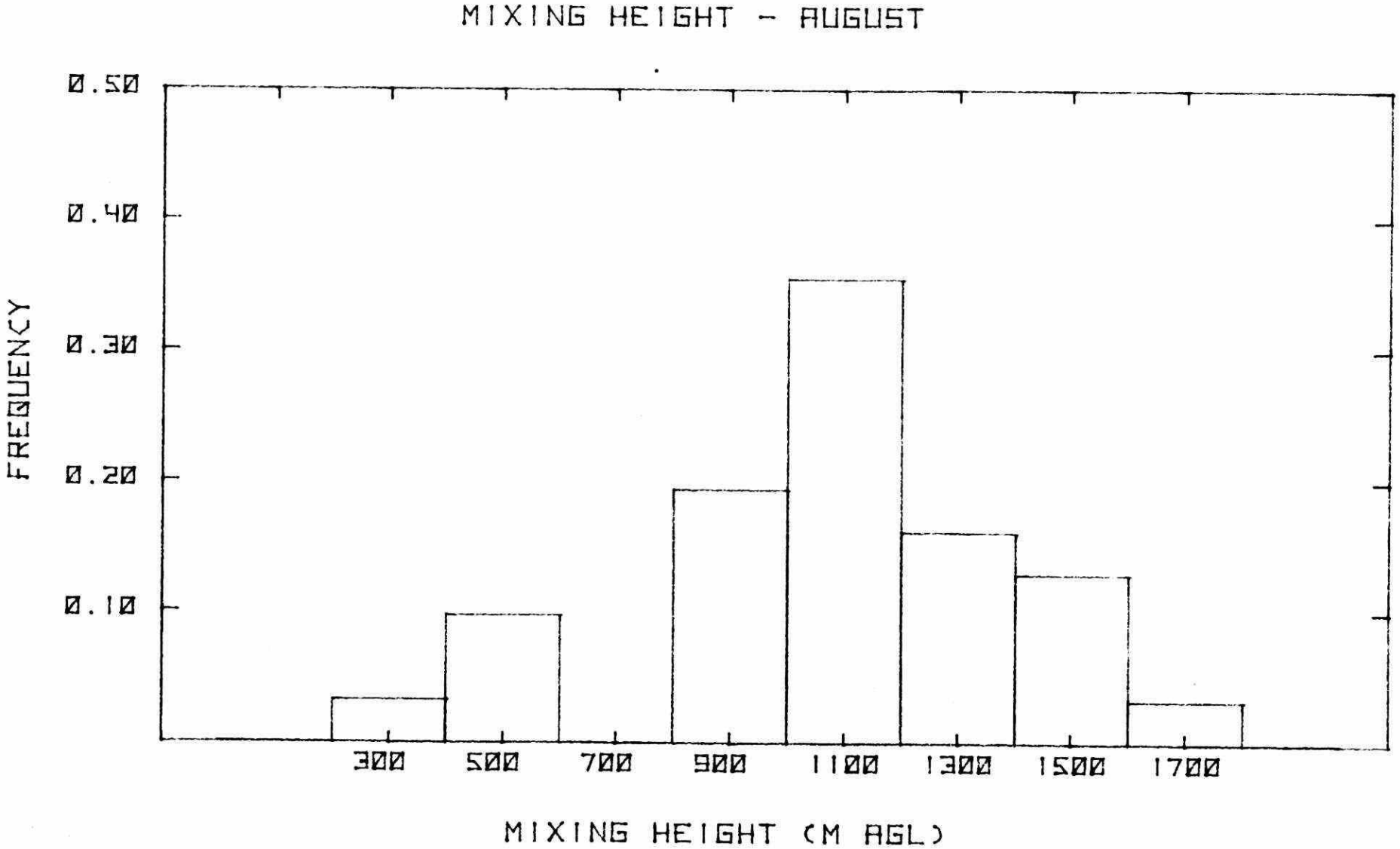


Figure 11: Mixing Height Frequency Distribution - August

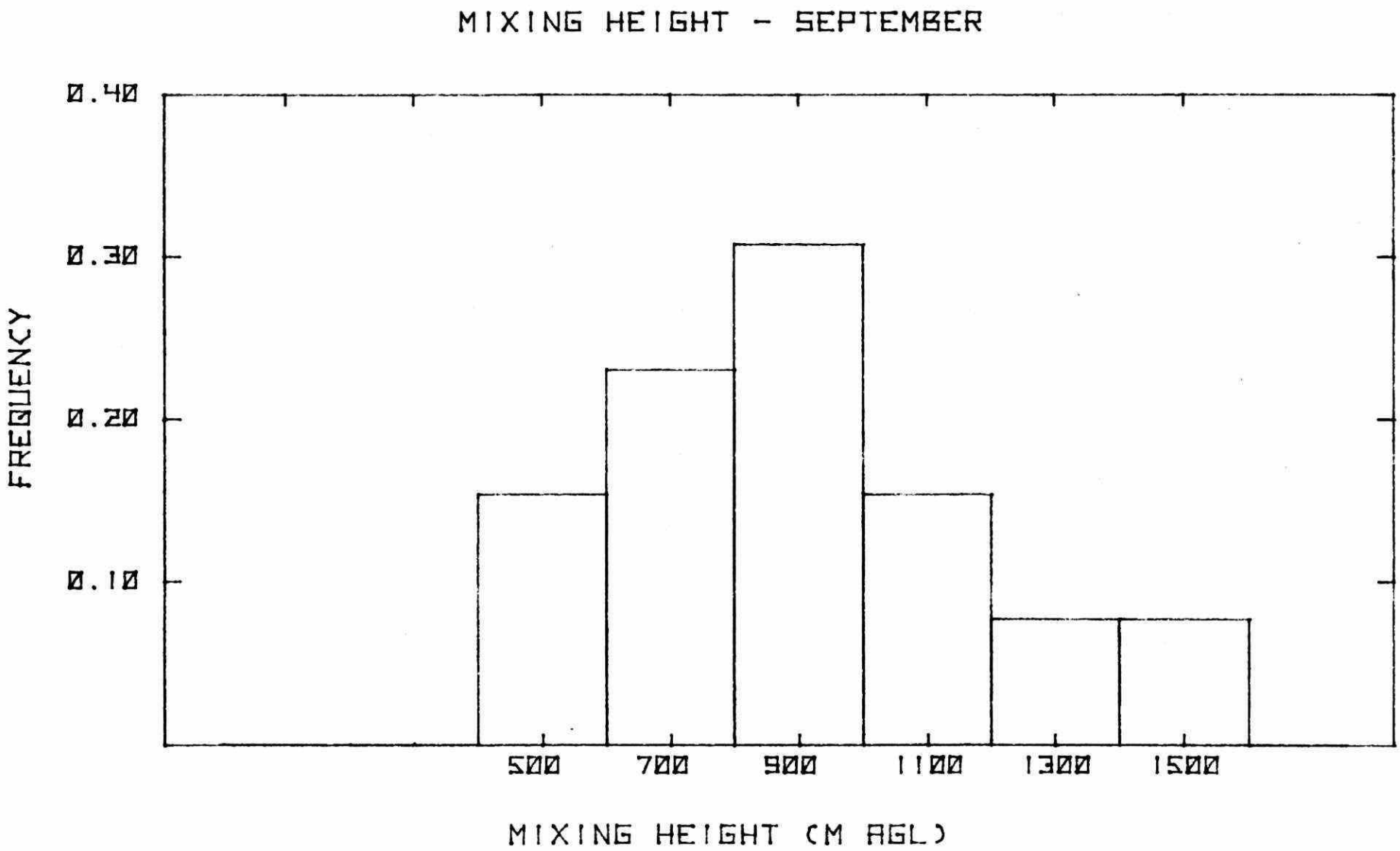


Figure 12: Mixing Height Frequency Distribution - September

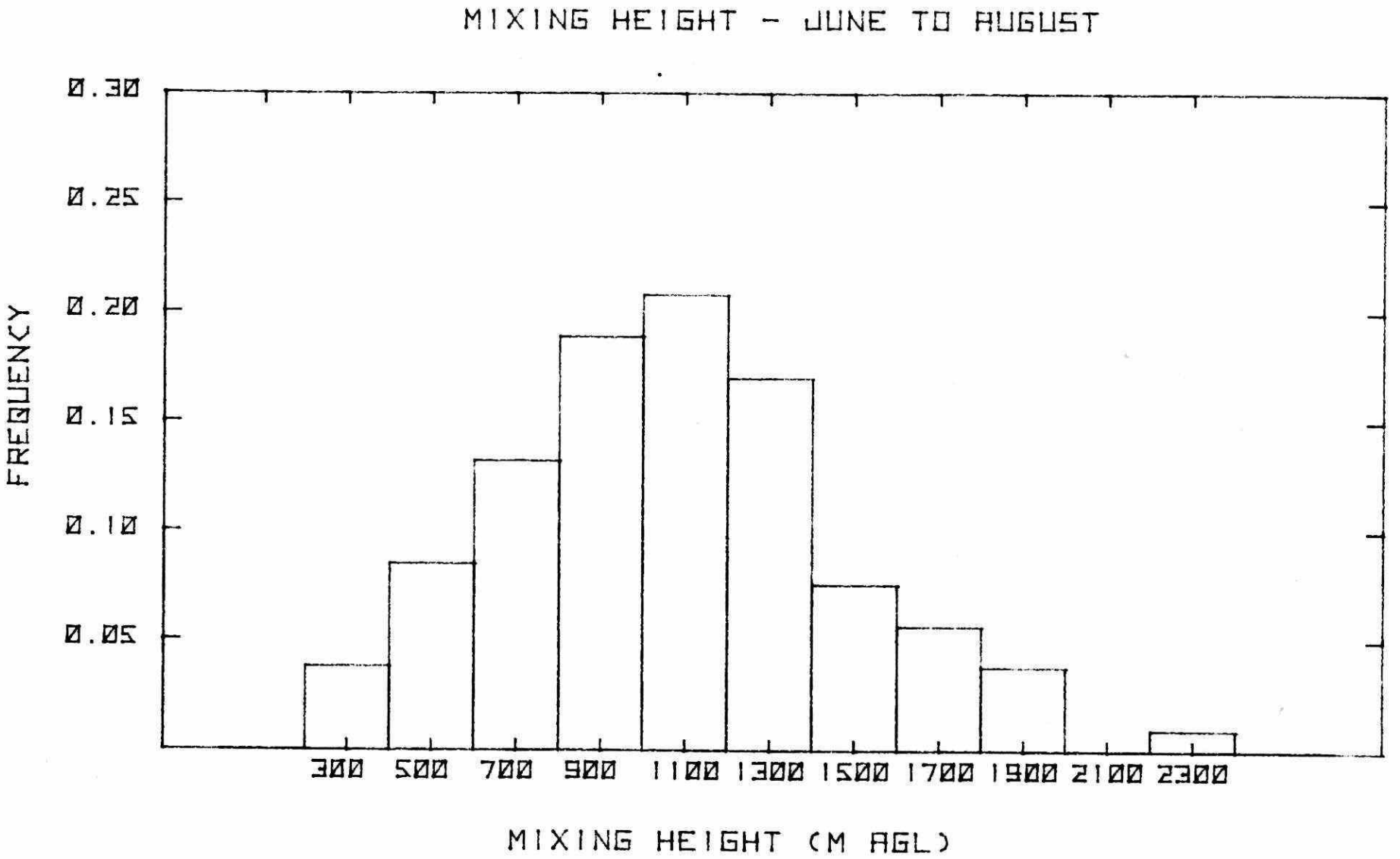


Figure 13: Mixing Height Frequency Distribution - June to August

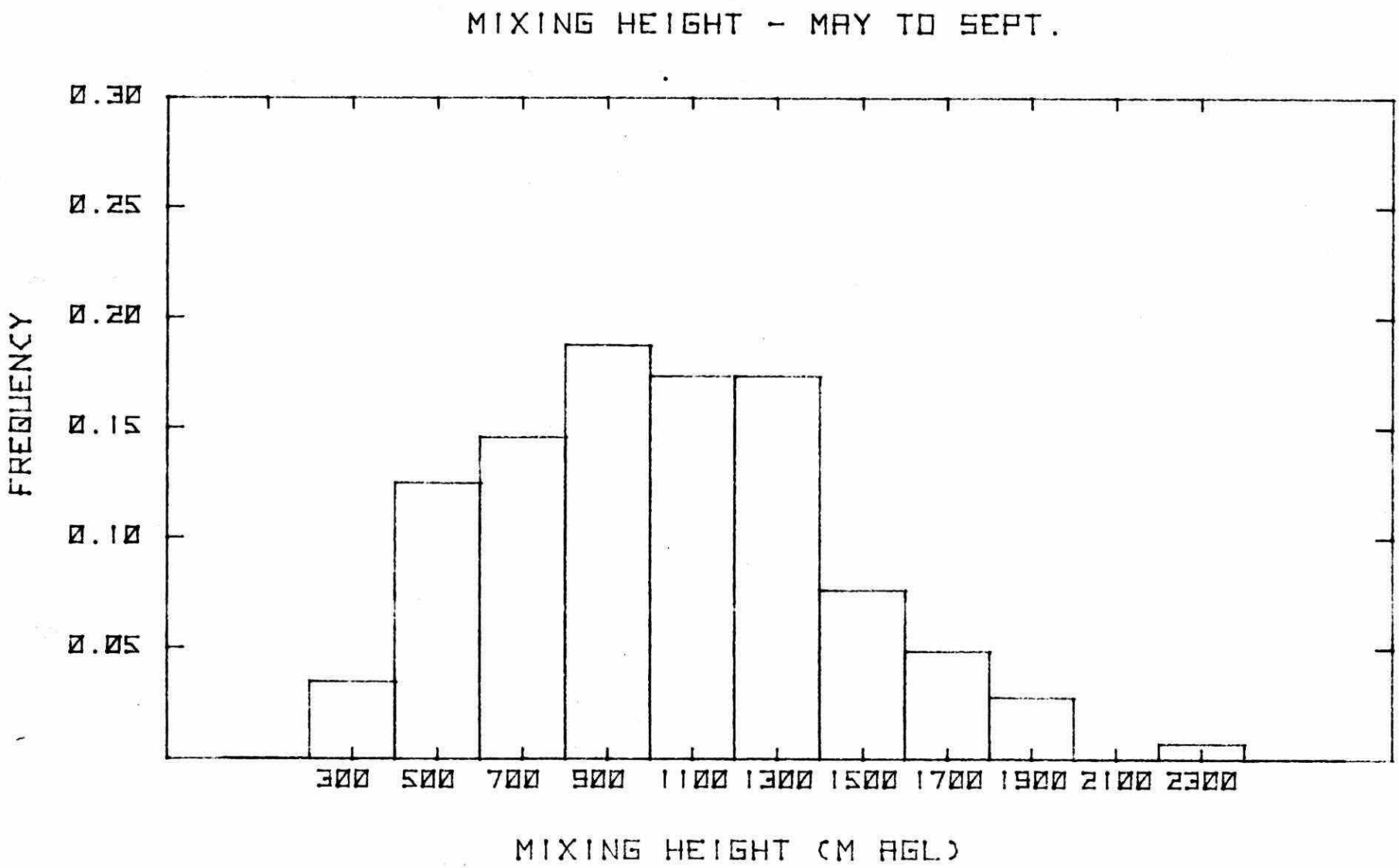


Figure 14: Mixing Height Frequency Distribution - May to September

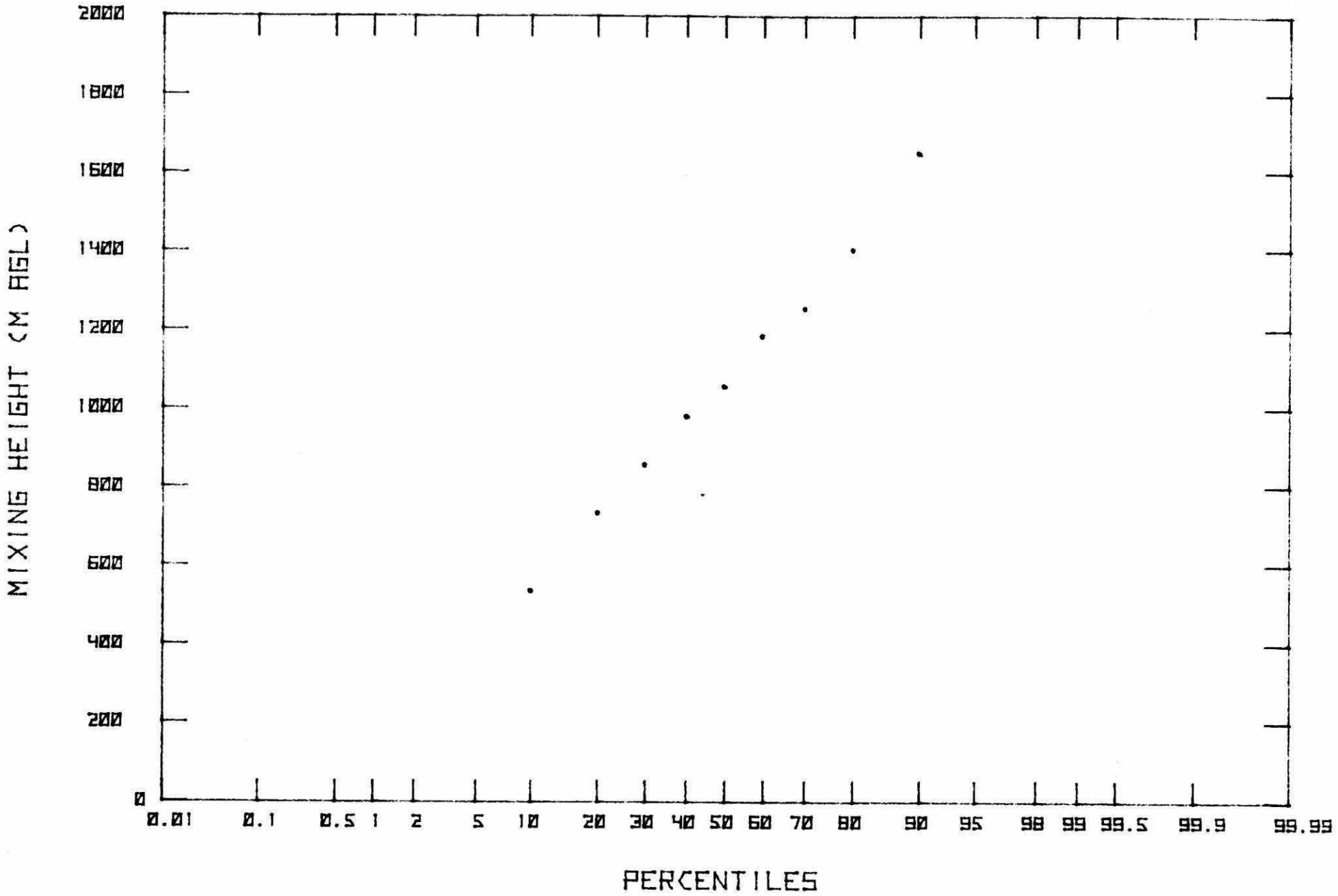


Figure 15: Mixing Height Probability Plot - May to September

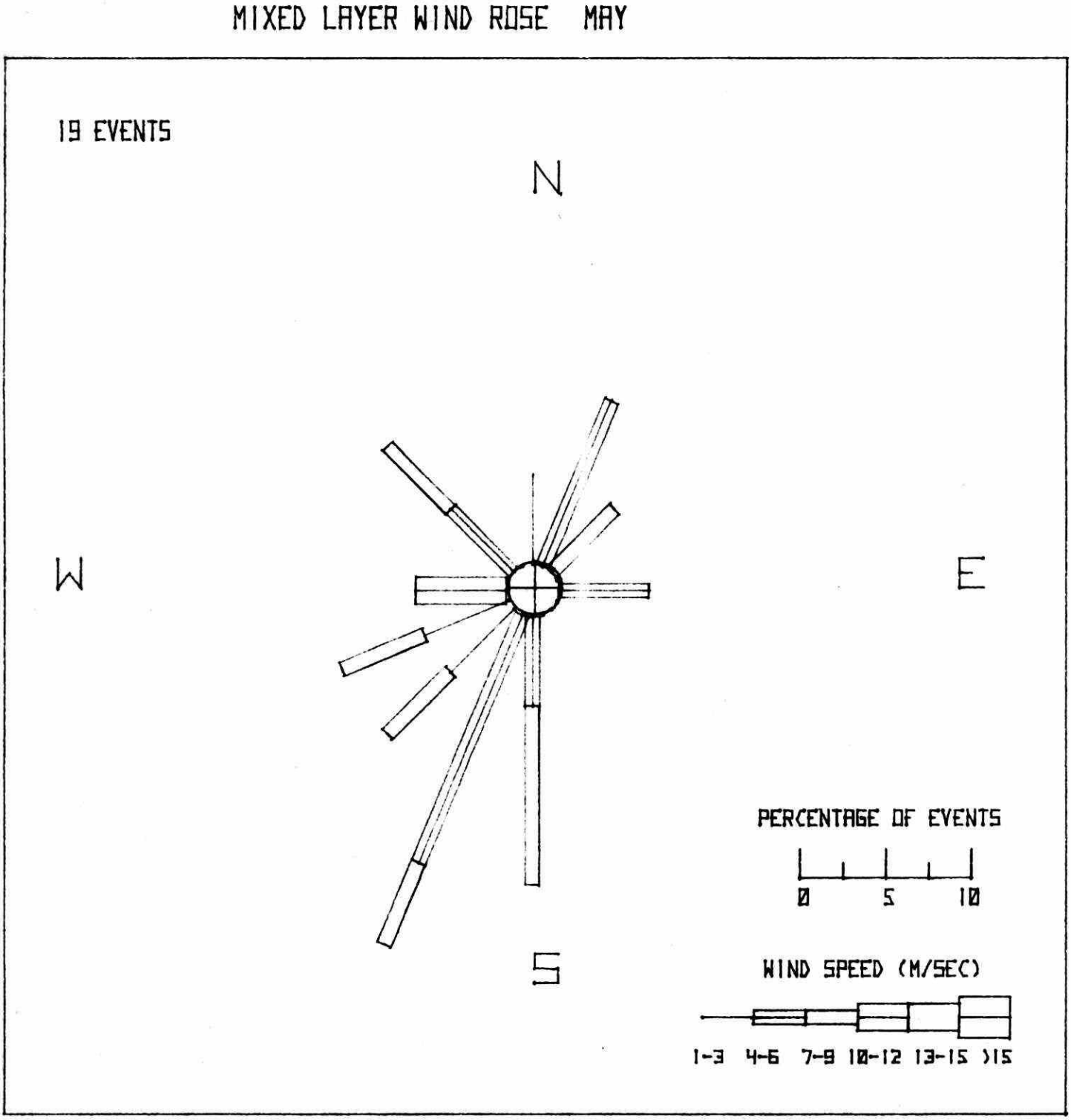


FIG. 16 Mixed Layer Wind Rose - May

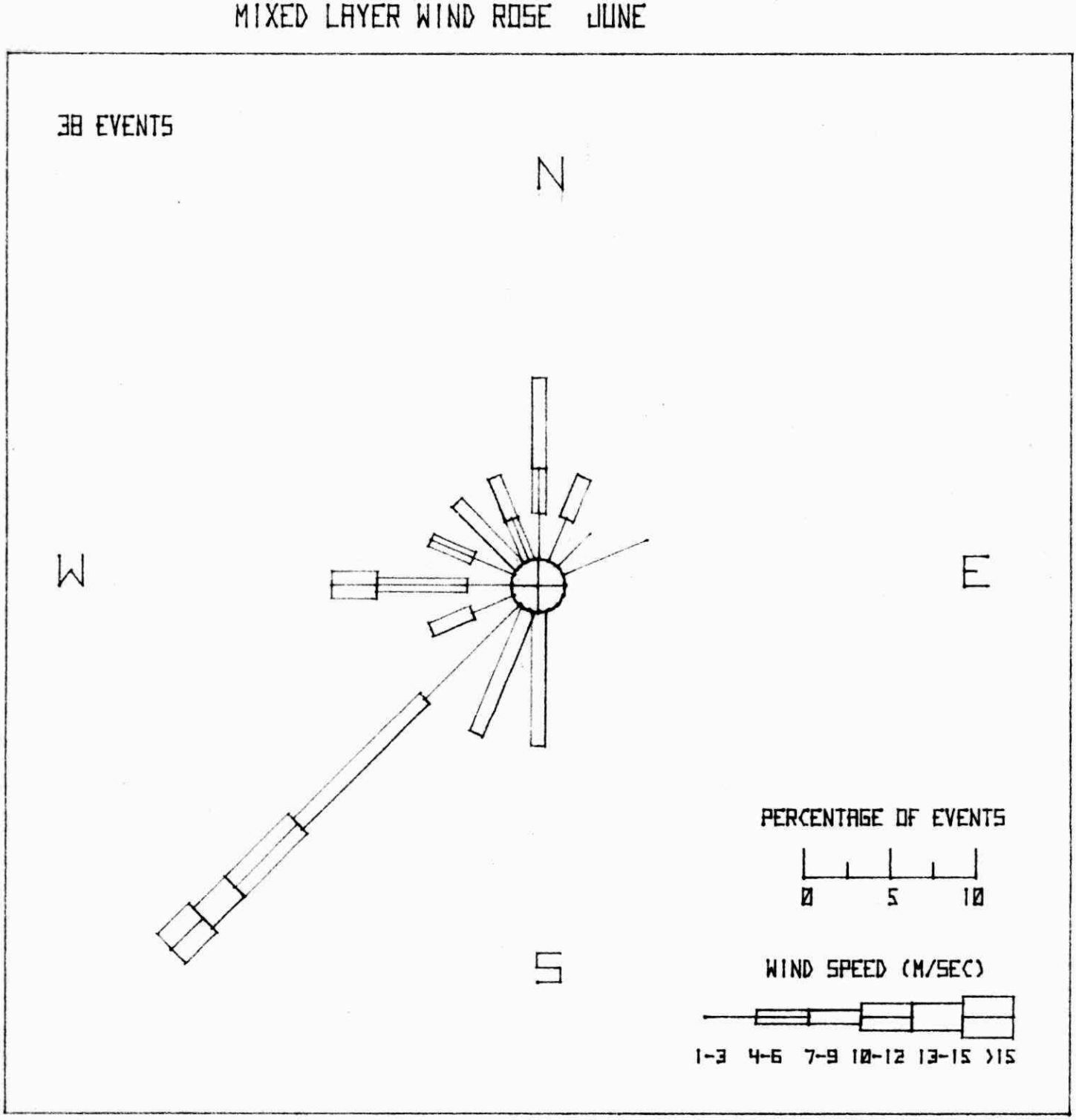


FIG. 17 Mixed Layer Wind Rose - June

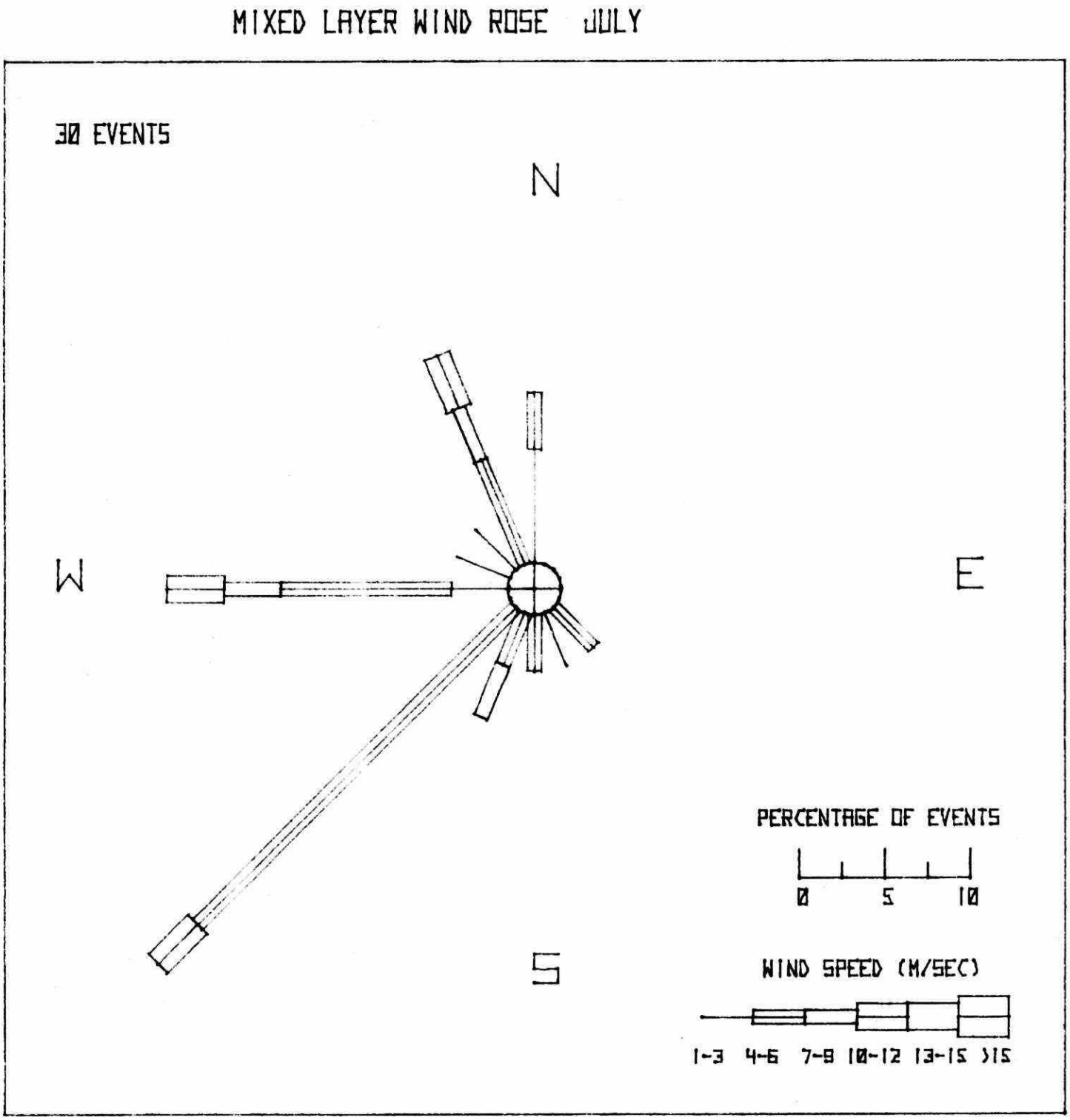


FIG. 18 Mixed Layer Wind Rose - July

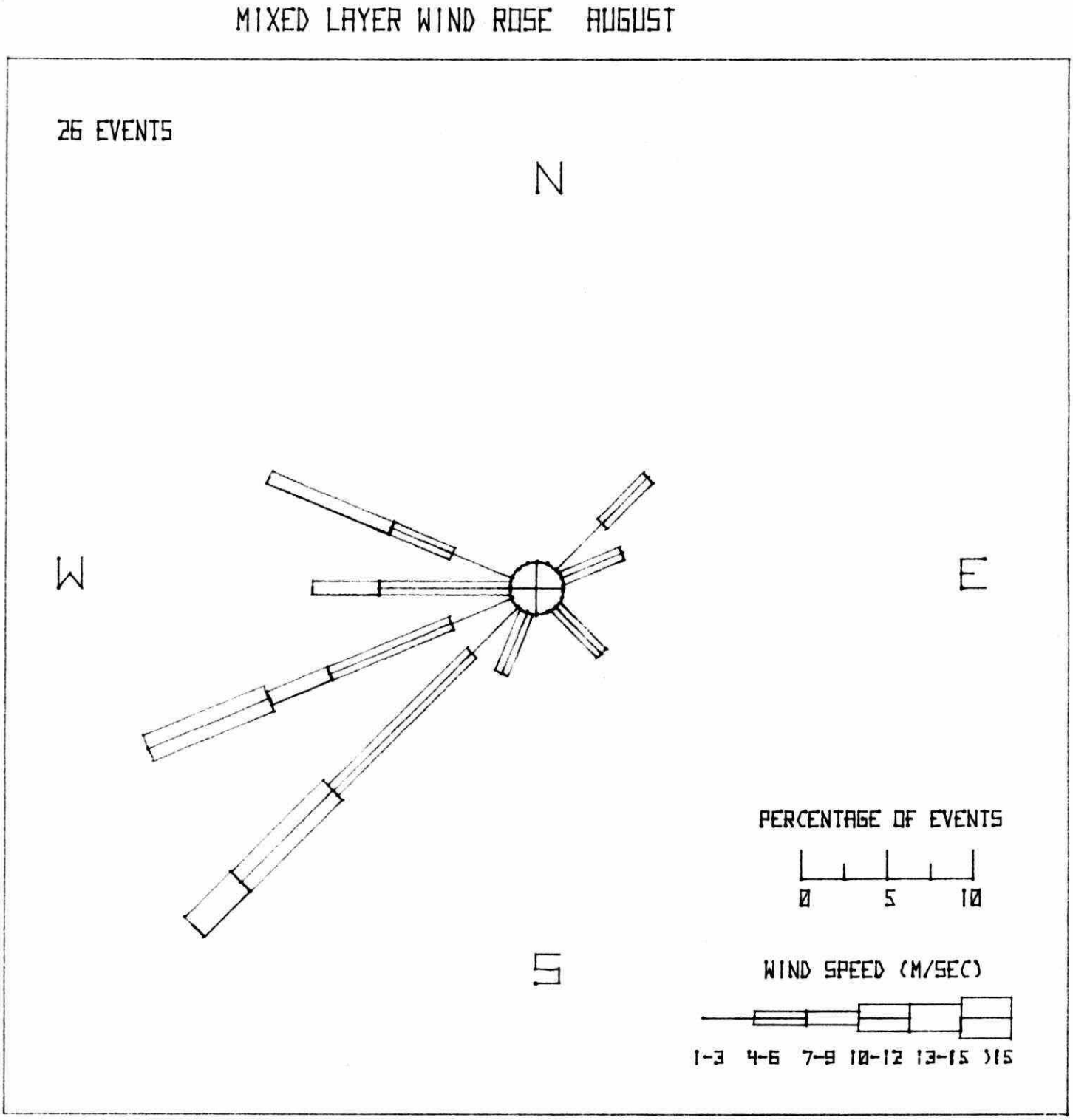


FIG. 19 Mixed Layer Wind Rose - August

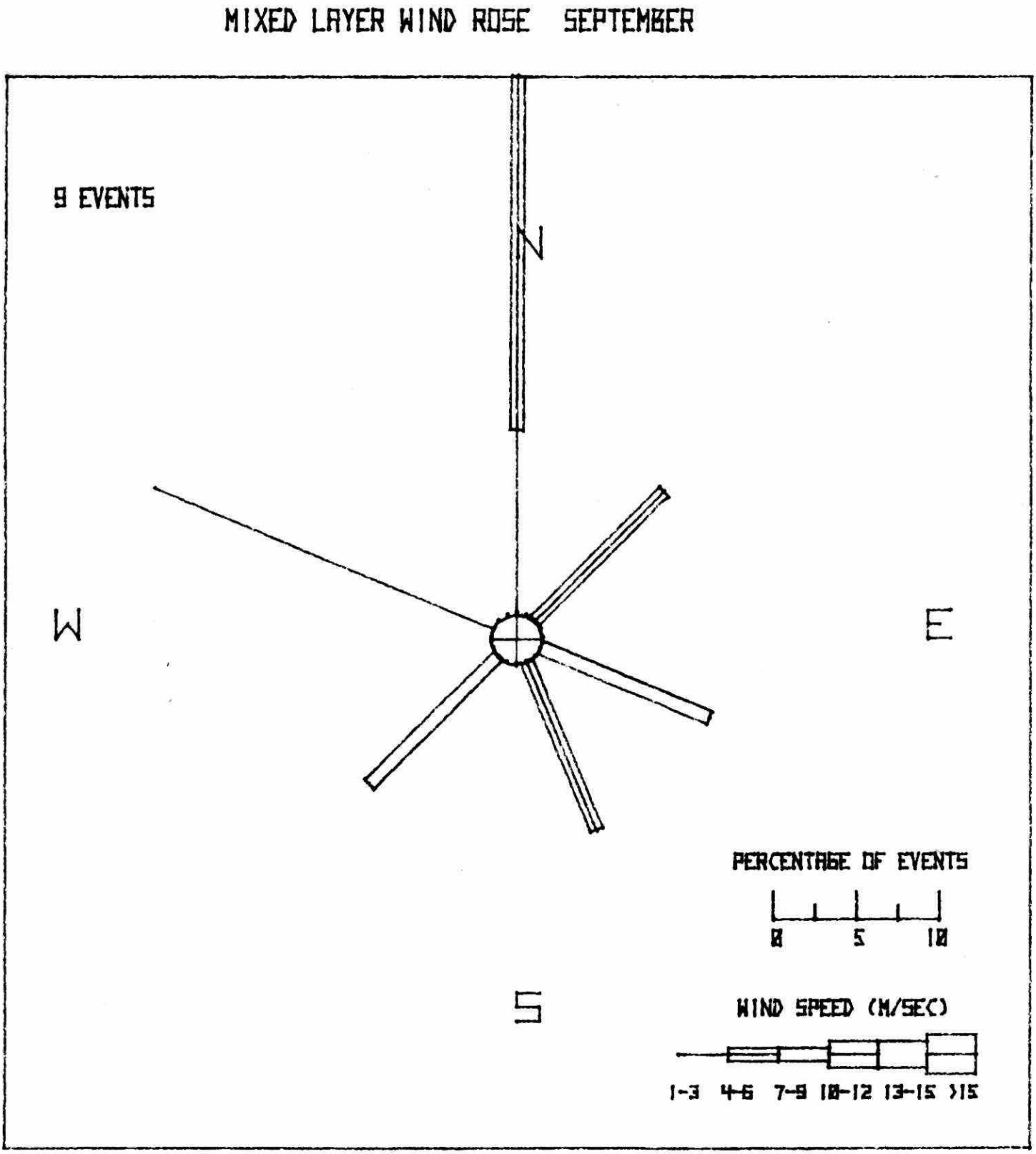


Fig: 20 Mixed Layer Wind Rose - September

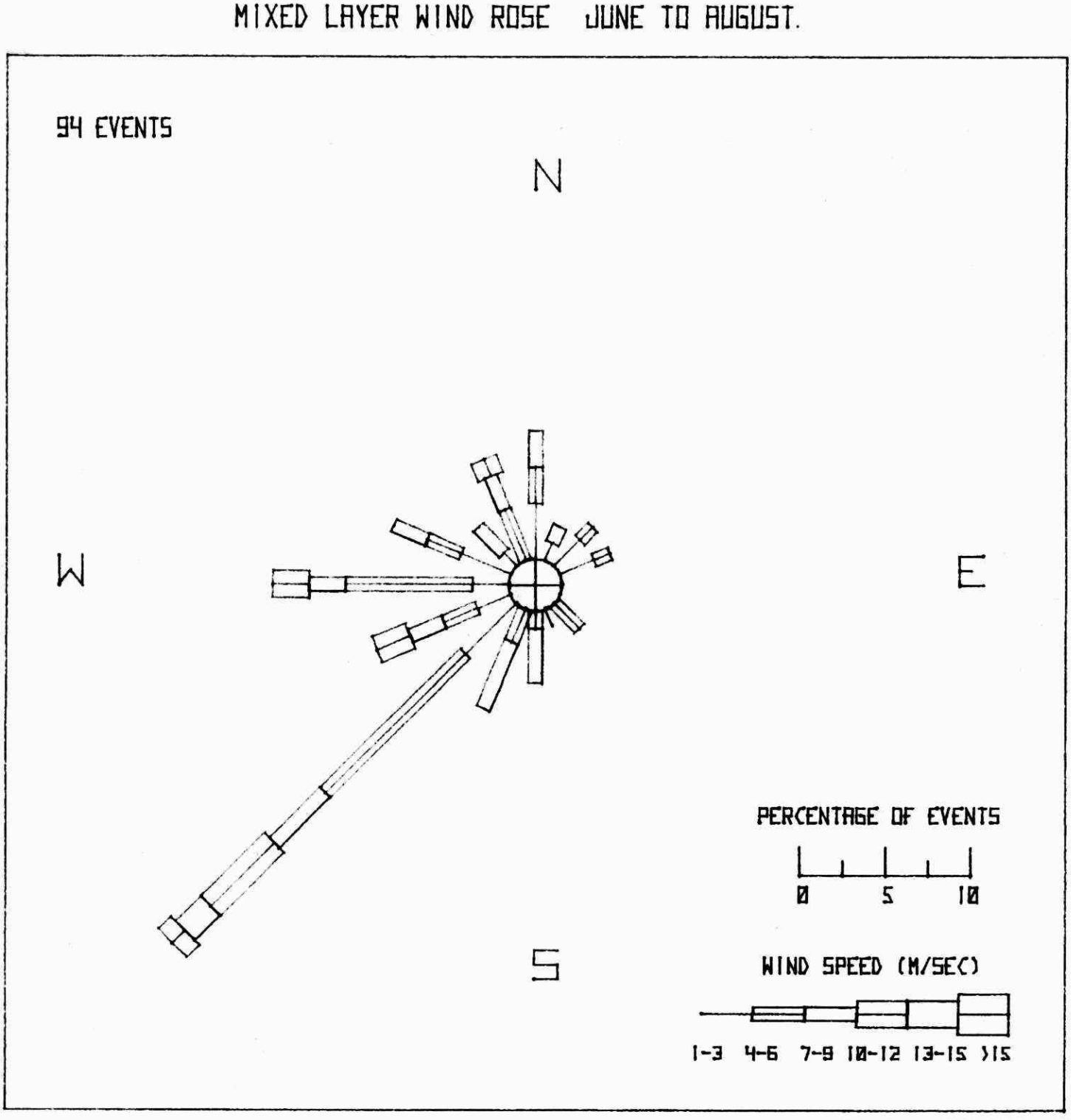


FIG. 21 Mixed Layer Wind Rose June - August

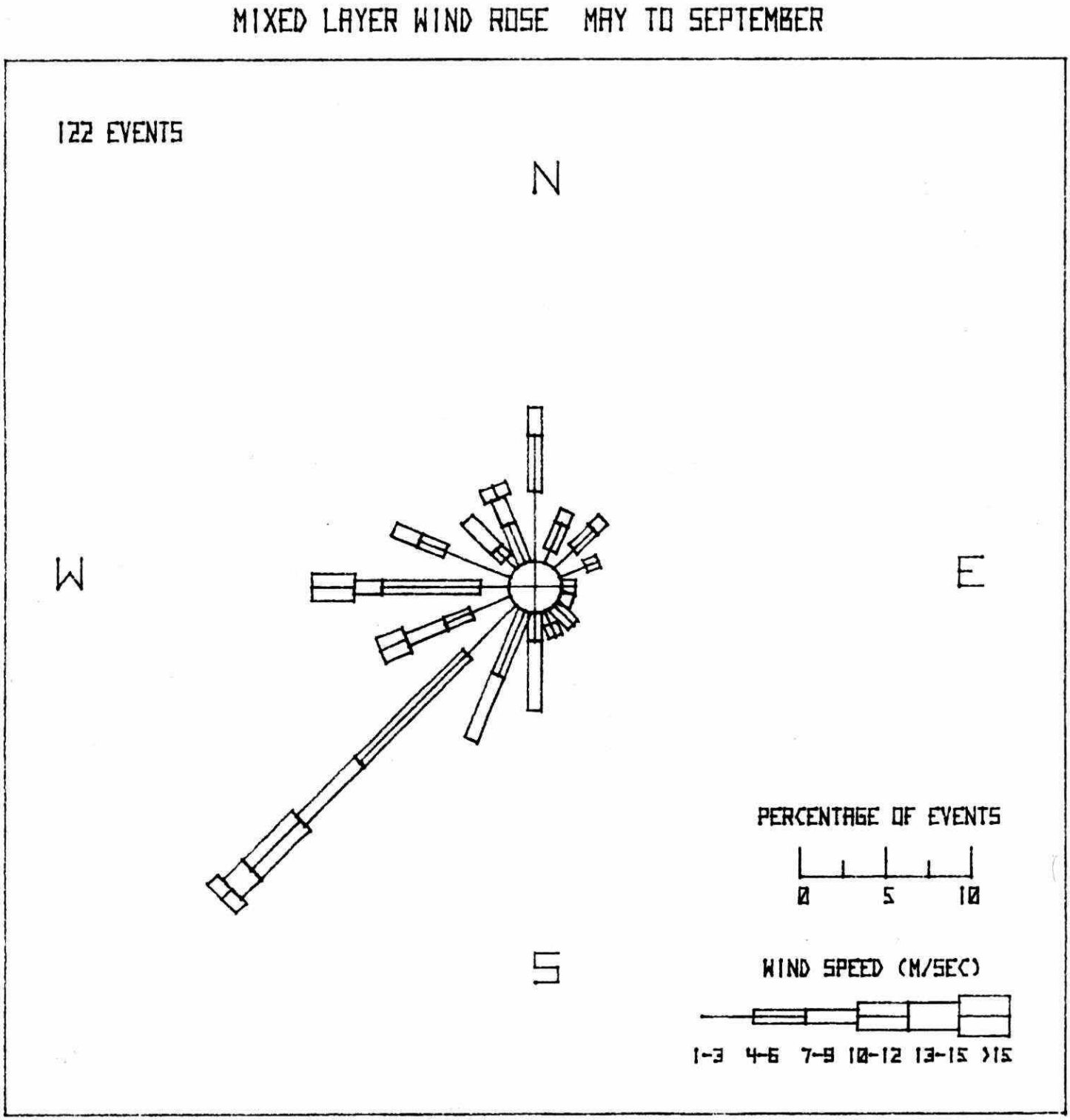


Fig: 22 Mixed Layer Wind Rose May -- September

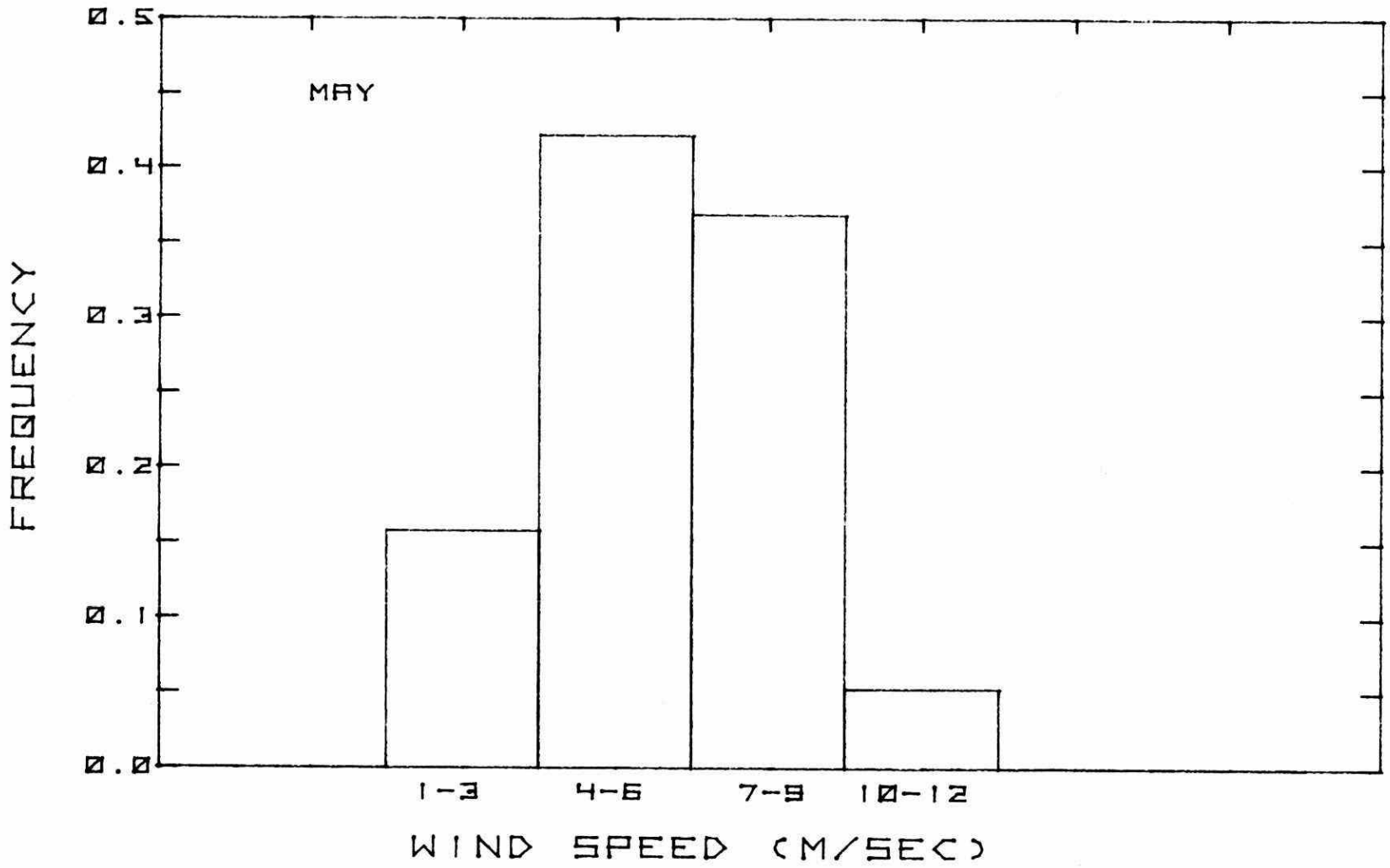


FIGURE 23
MIXED LAYER WIND SPEED

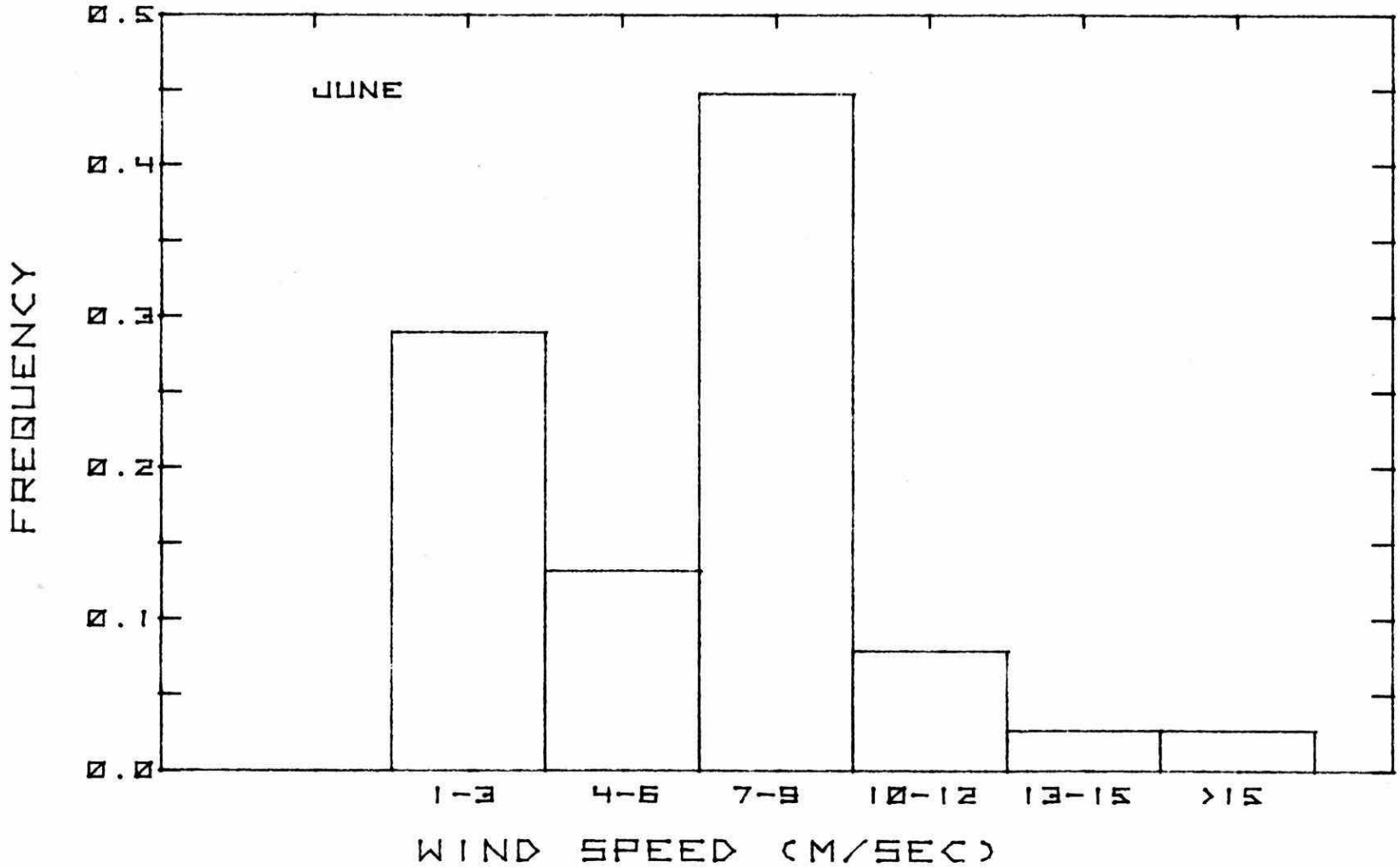


FIGURE 24

MIXED LAYER WIND SPEED

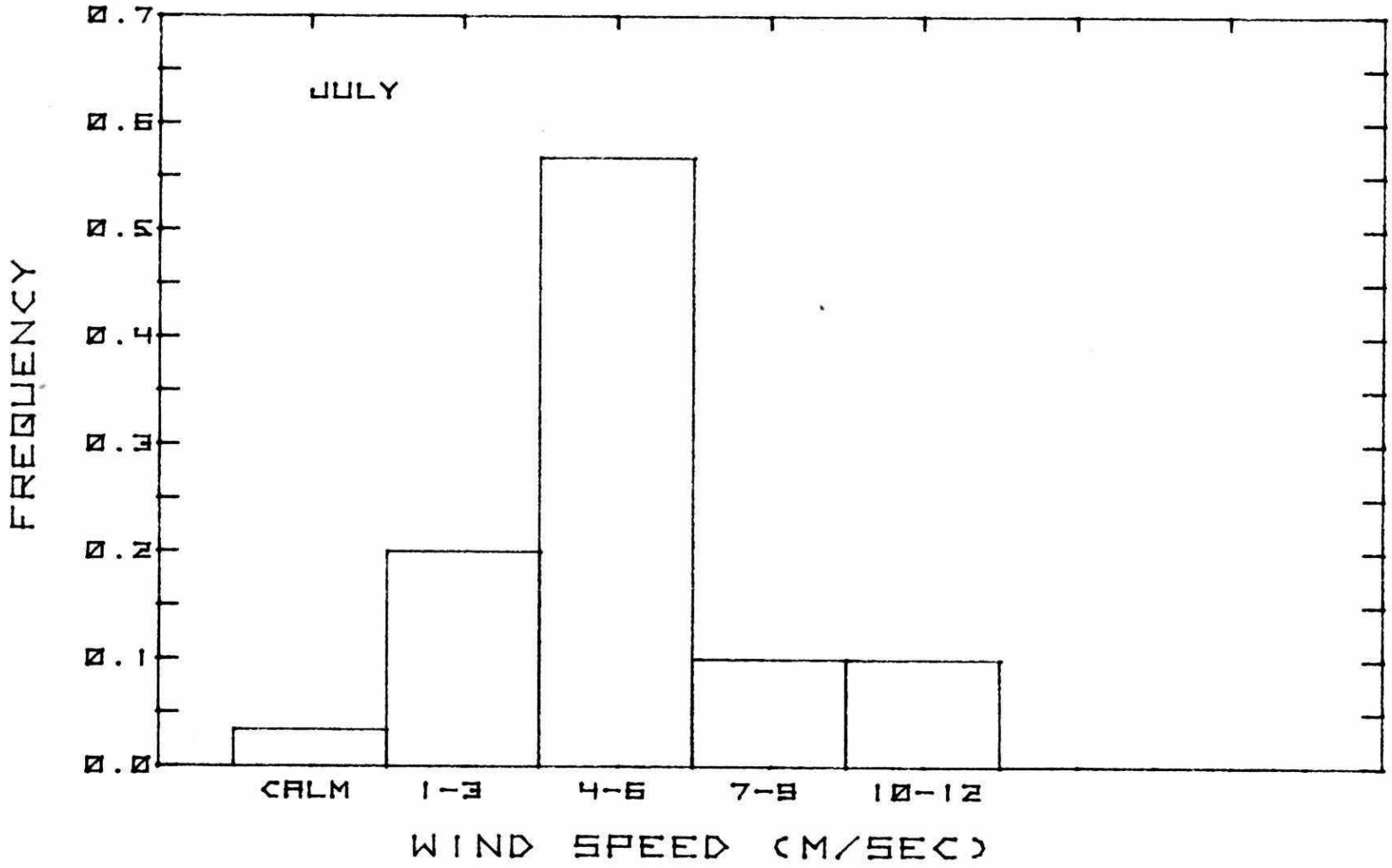


FIGURE 25

MIXED LAYER WIND SPEED

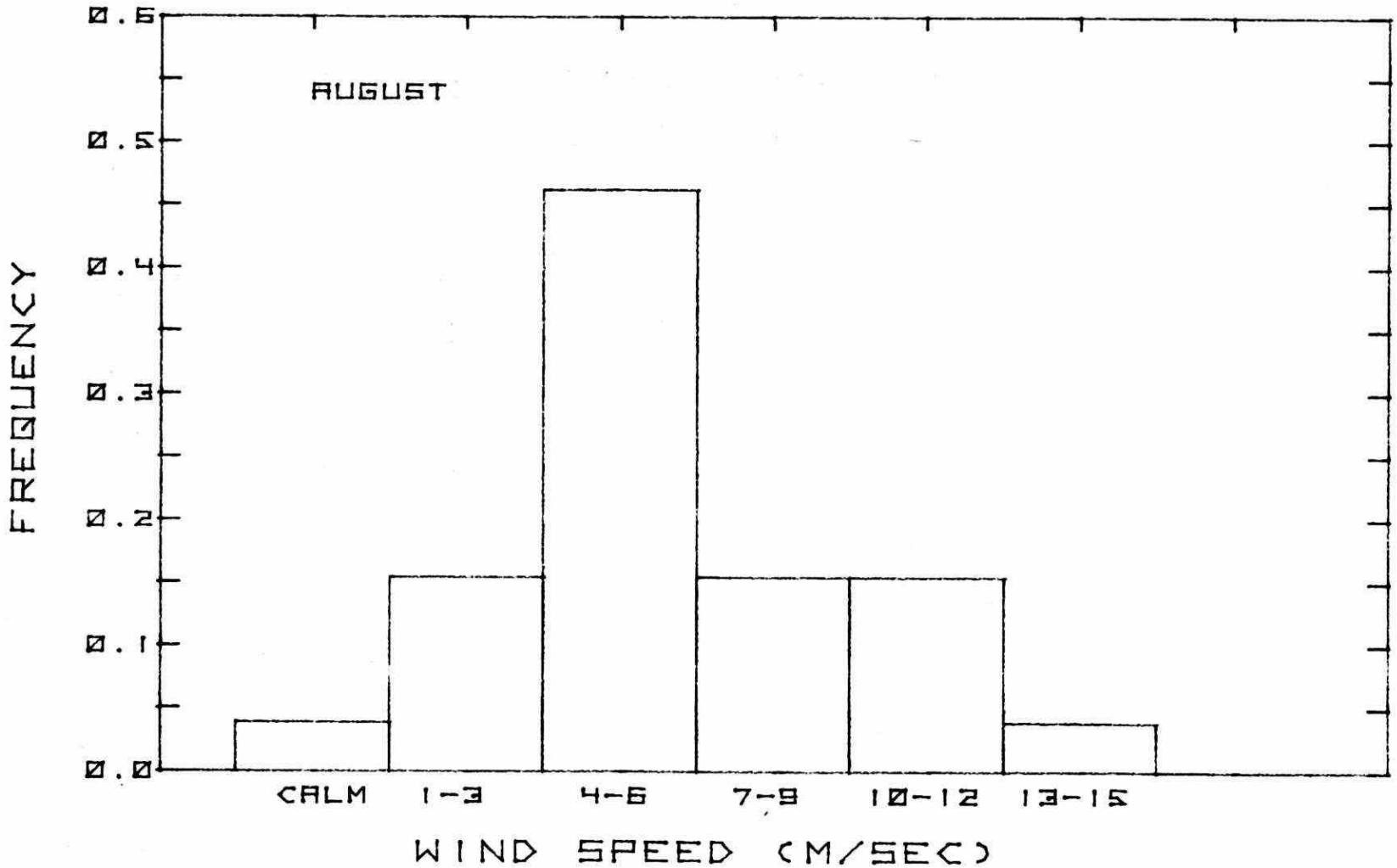


FIGURE 26

MIXED LAYER WIND SPEED

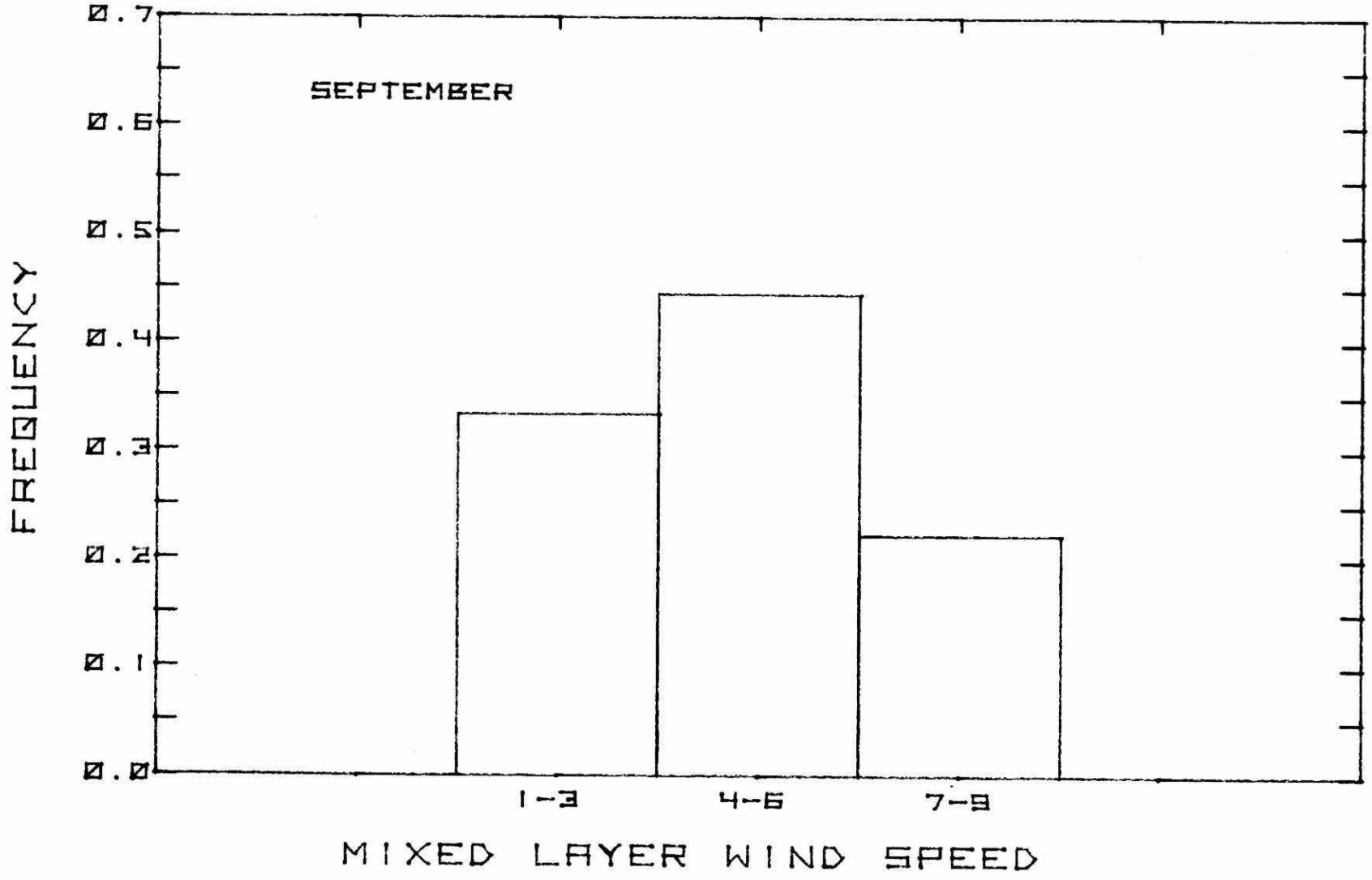


FIGURE 27

MIXED LAYER WIND SPEED

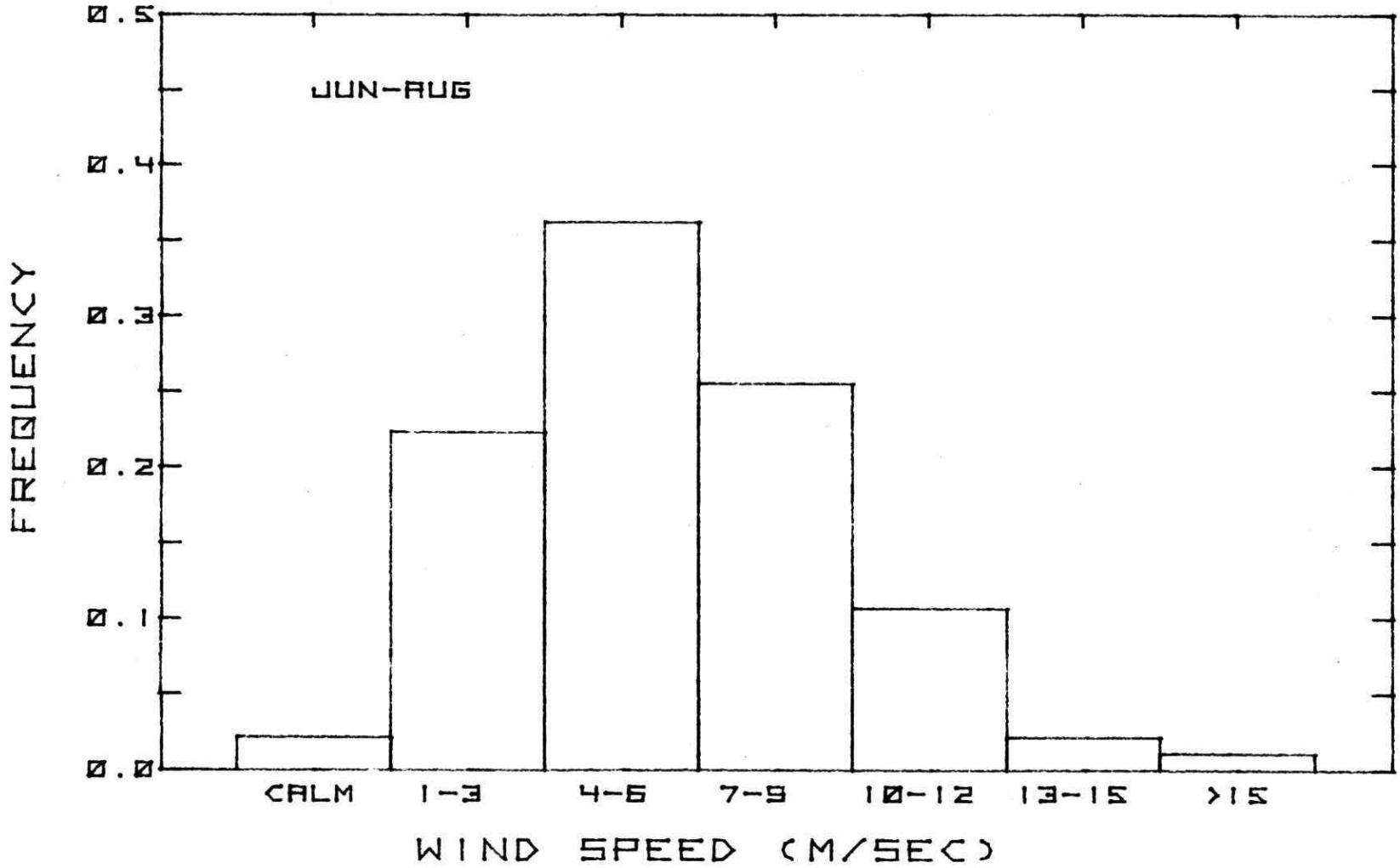


FIGURE 28

MIXED LAYER WIND SPEED

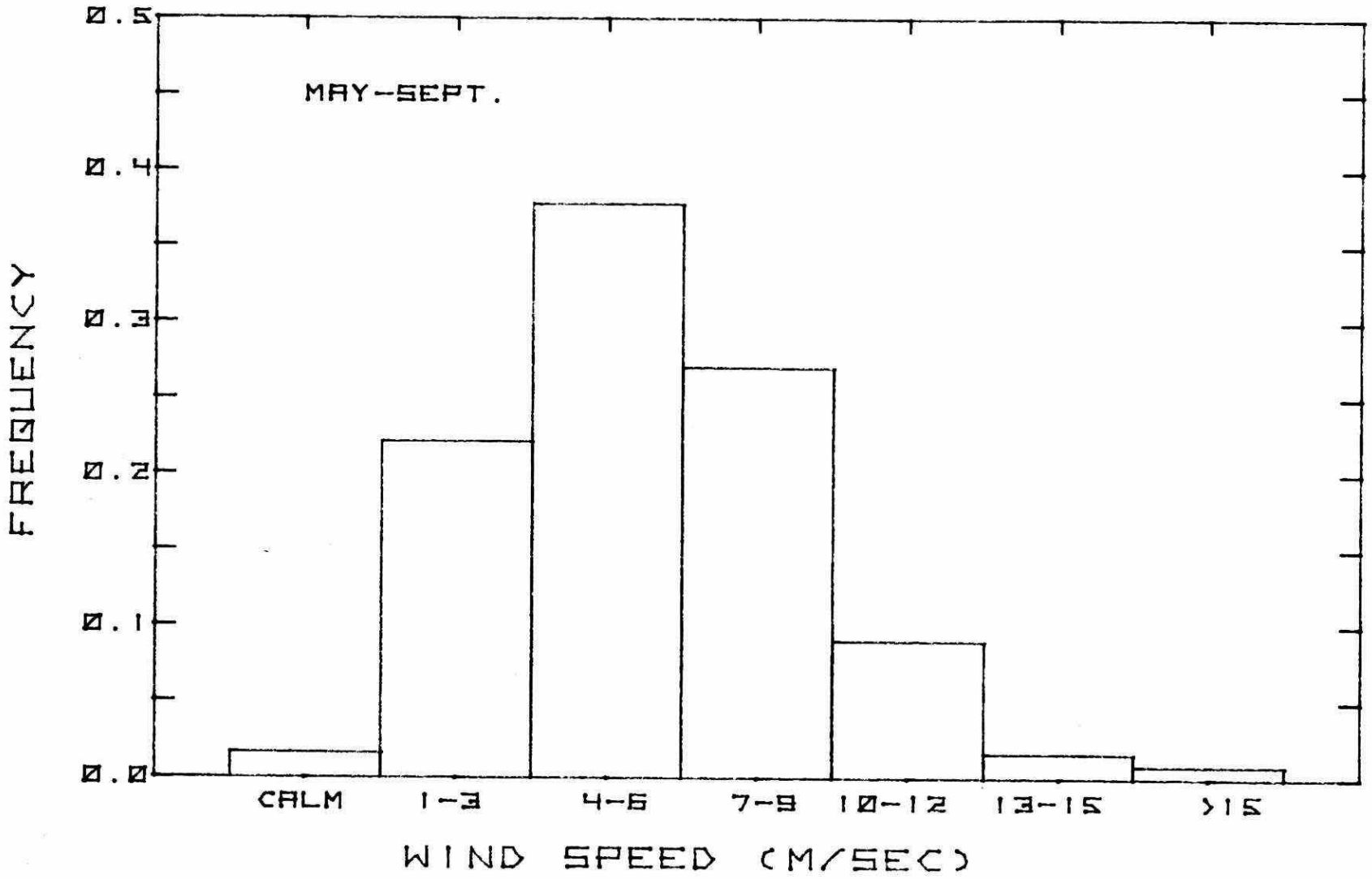


FIGURE 29

MIXED LAYER WIND SPEED

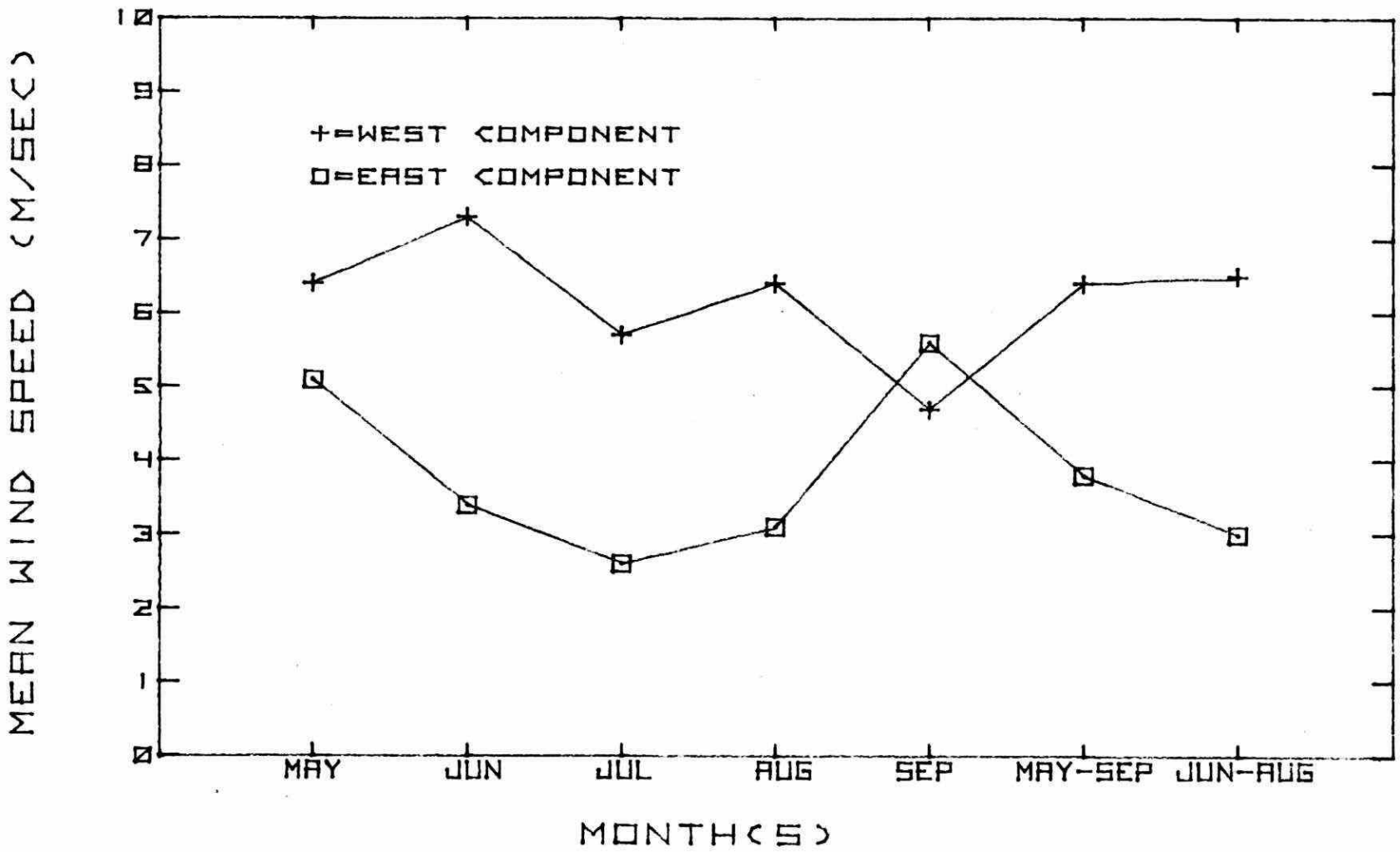


FIGURE 30

MIXED LAYER WINDS

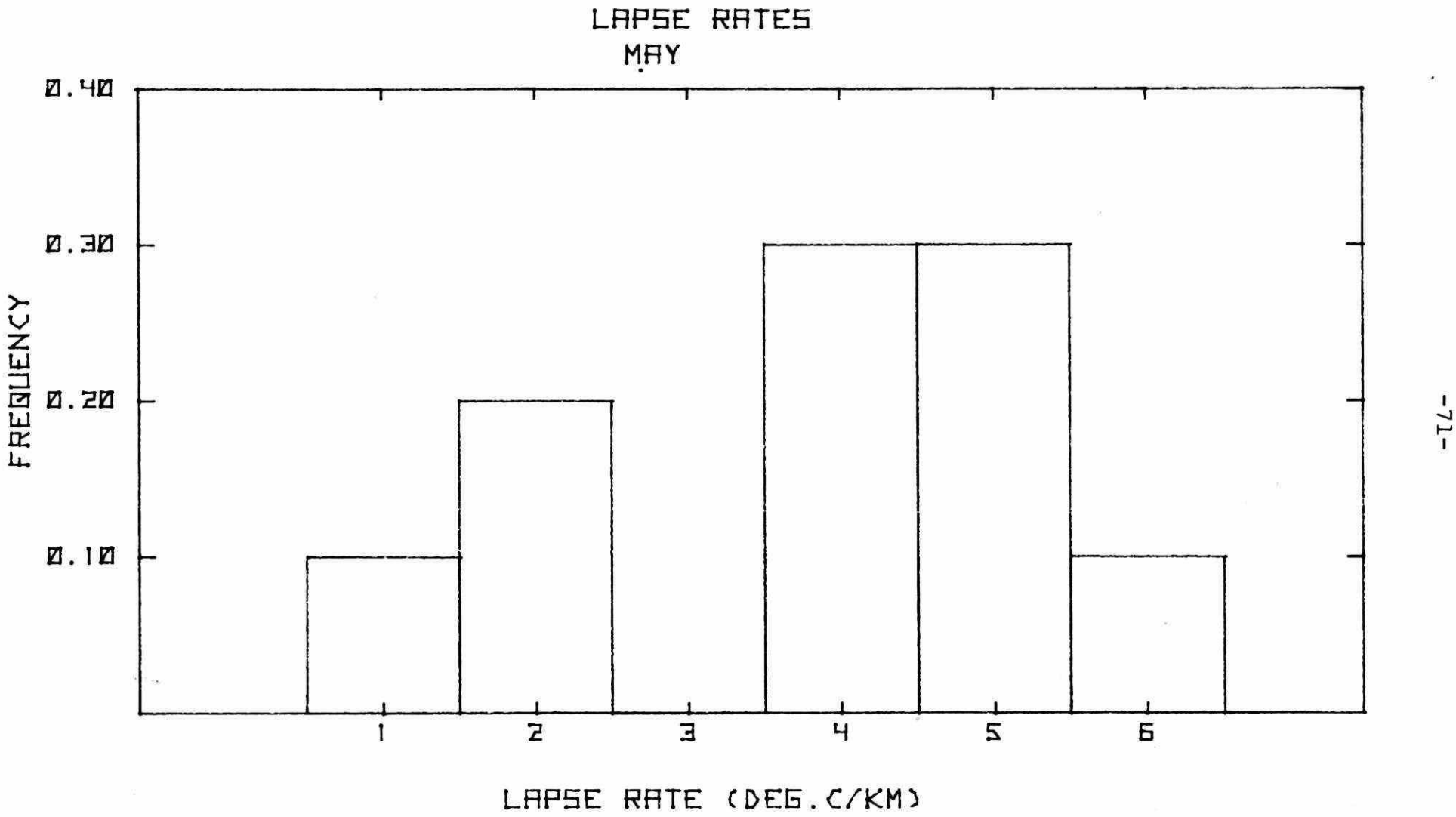


Figure 31: Potential Temperature Lapse Rate Distribution - May

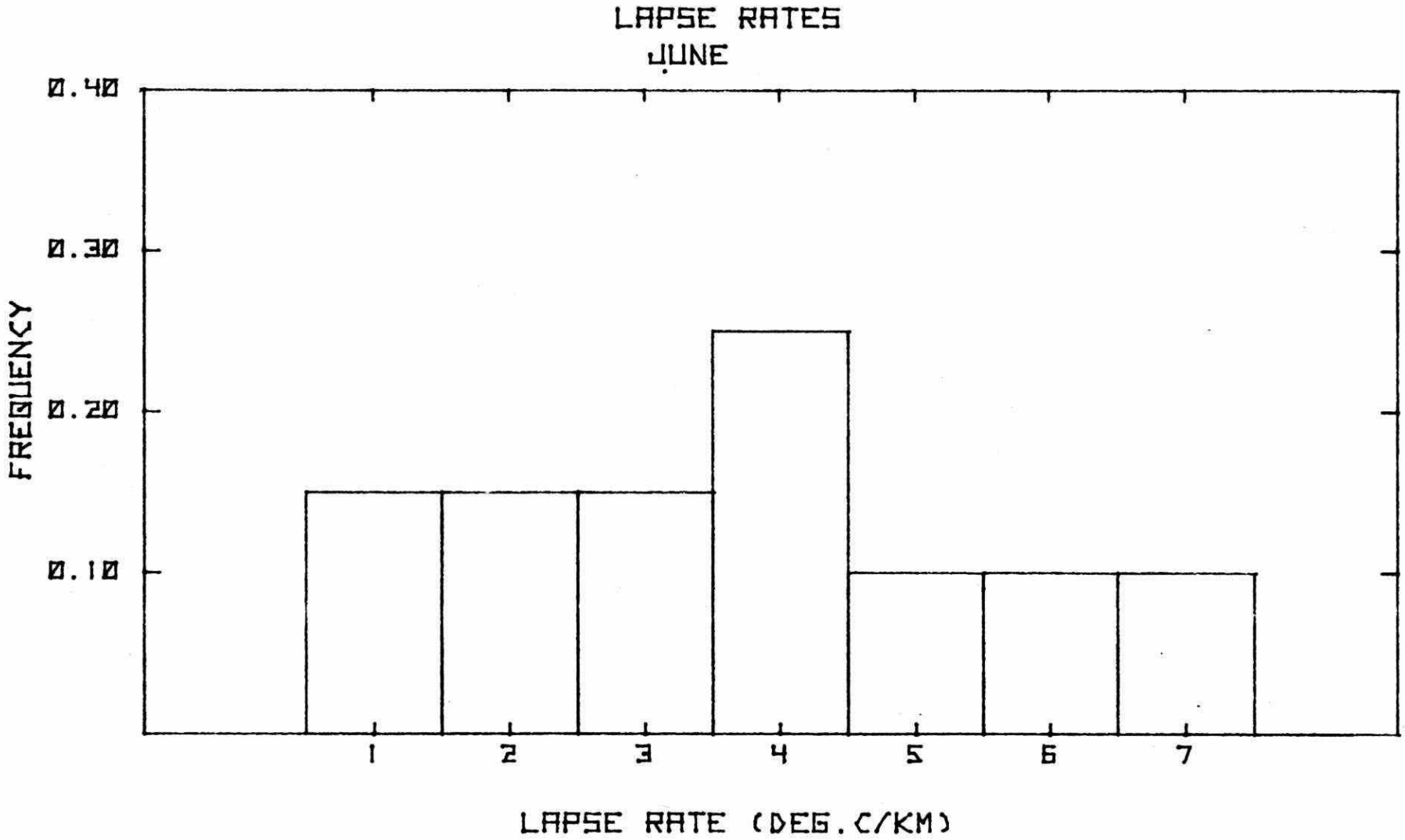


Figure 32: Potential Temperature Lapse Rate Distribution - June

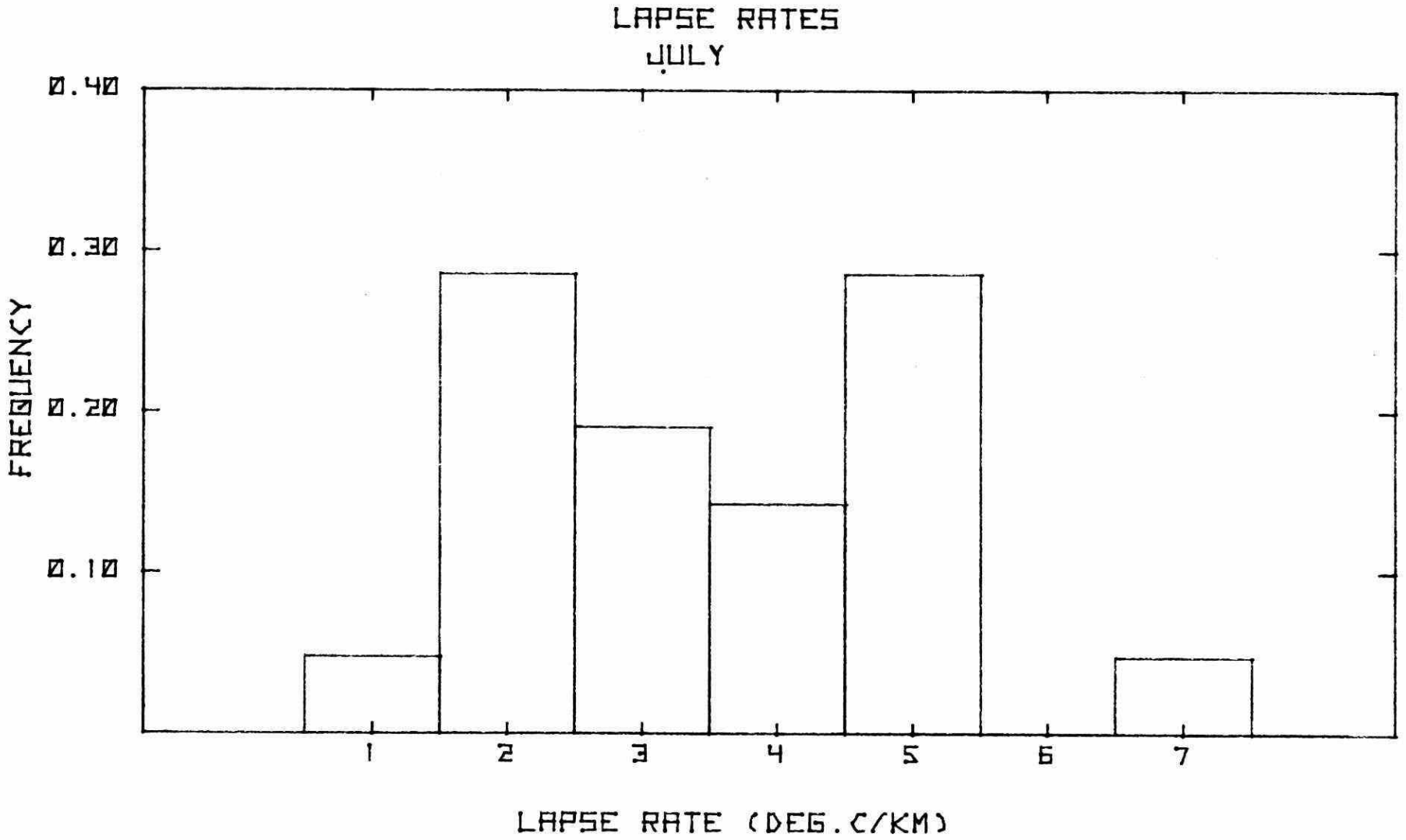


Figure 33: Potential Temperature Lapse Rate Distribution - July

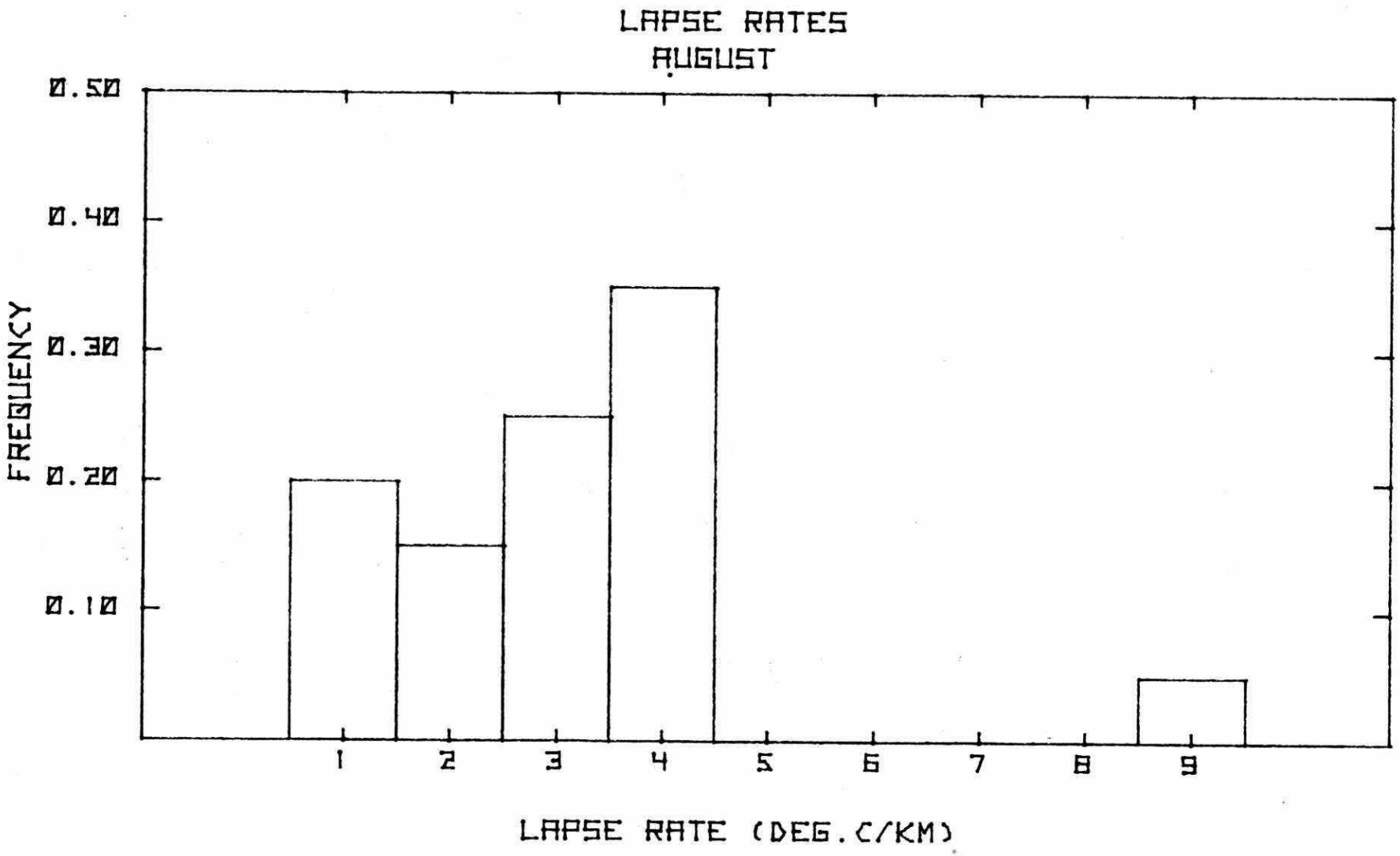


Figure 34: Potential Temperature Lapse Rate Distribution - August

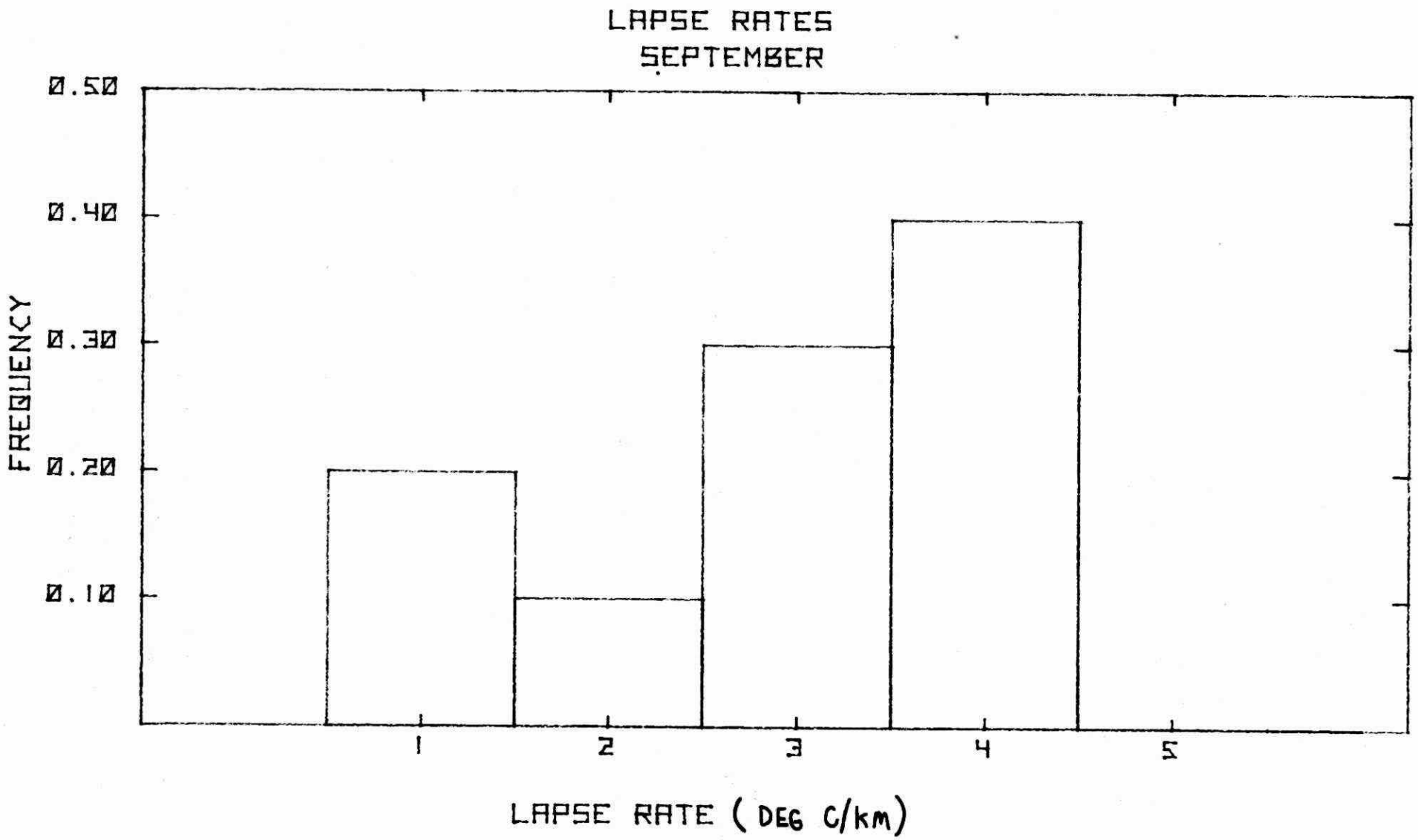


Figure 35: Potential Temperature Lapse Rate Distribution - September

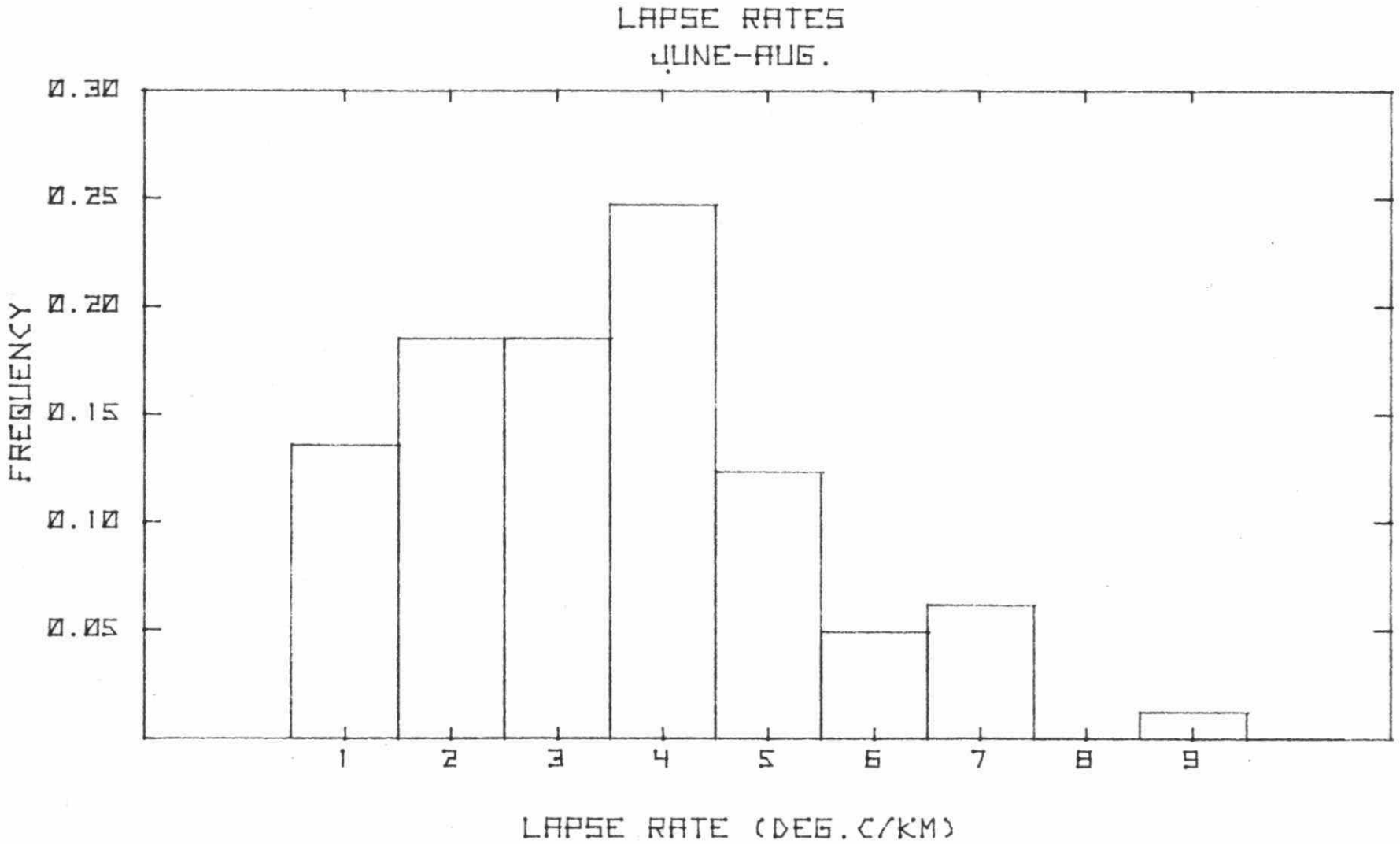


Figure 36: Potential Temperature Lapse Rate Distribution - June to August

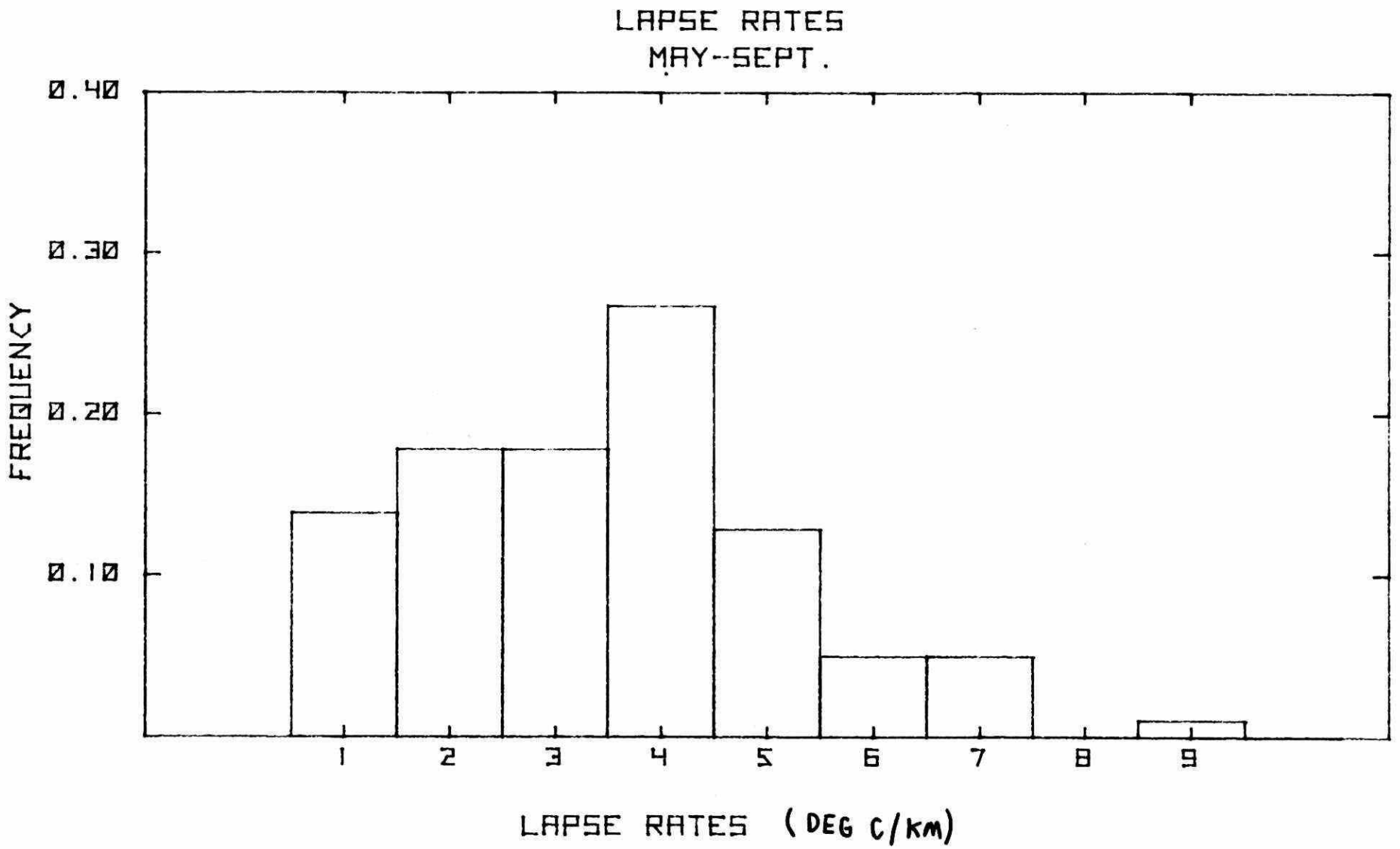


Figure 37: Potential Temperature Lapse Rate Distribution - May to September

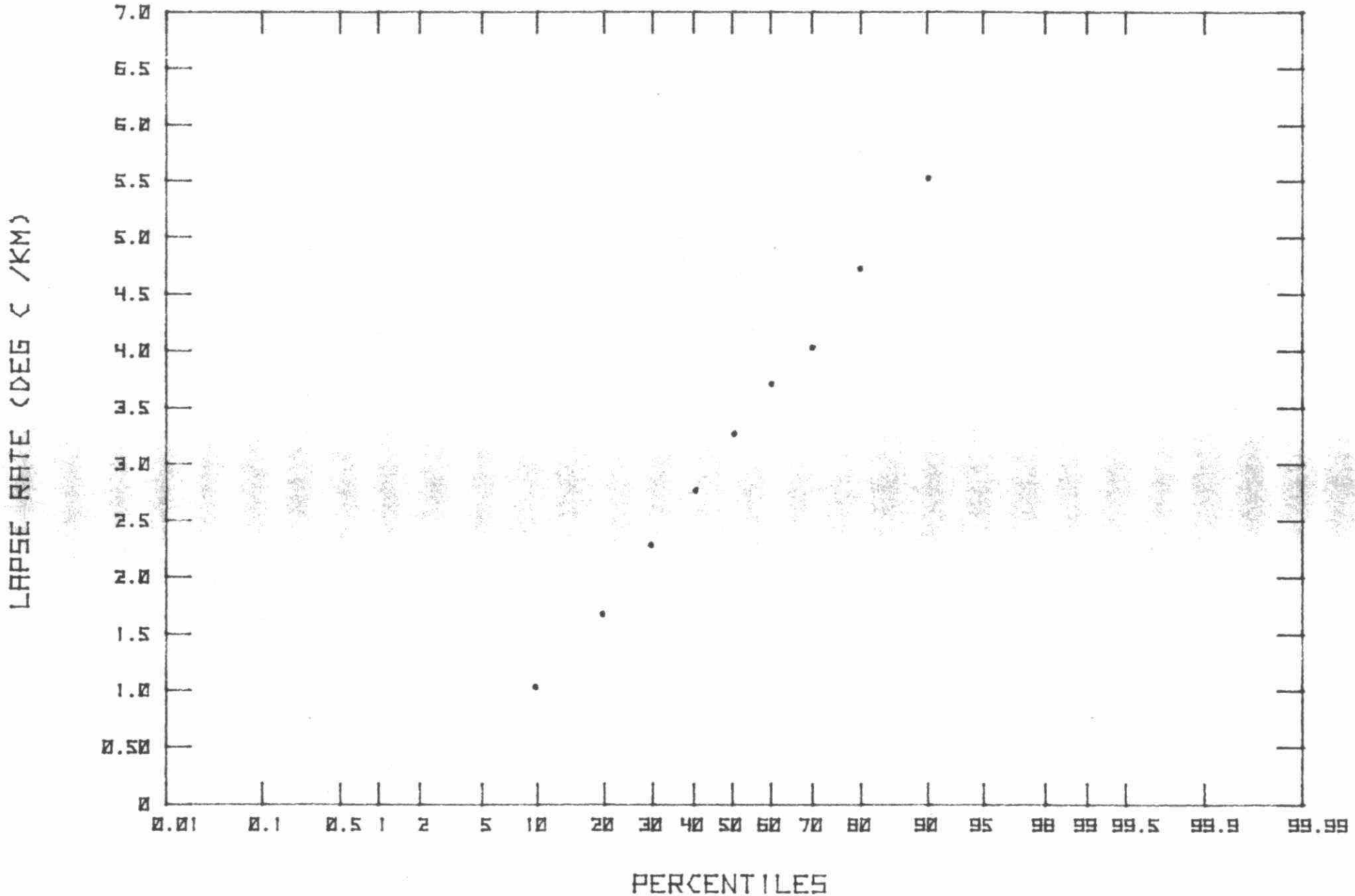


Figure 38: Potential Temperature Lapse Rate Probability Plot - May to September

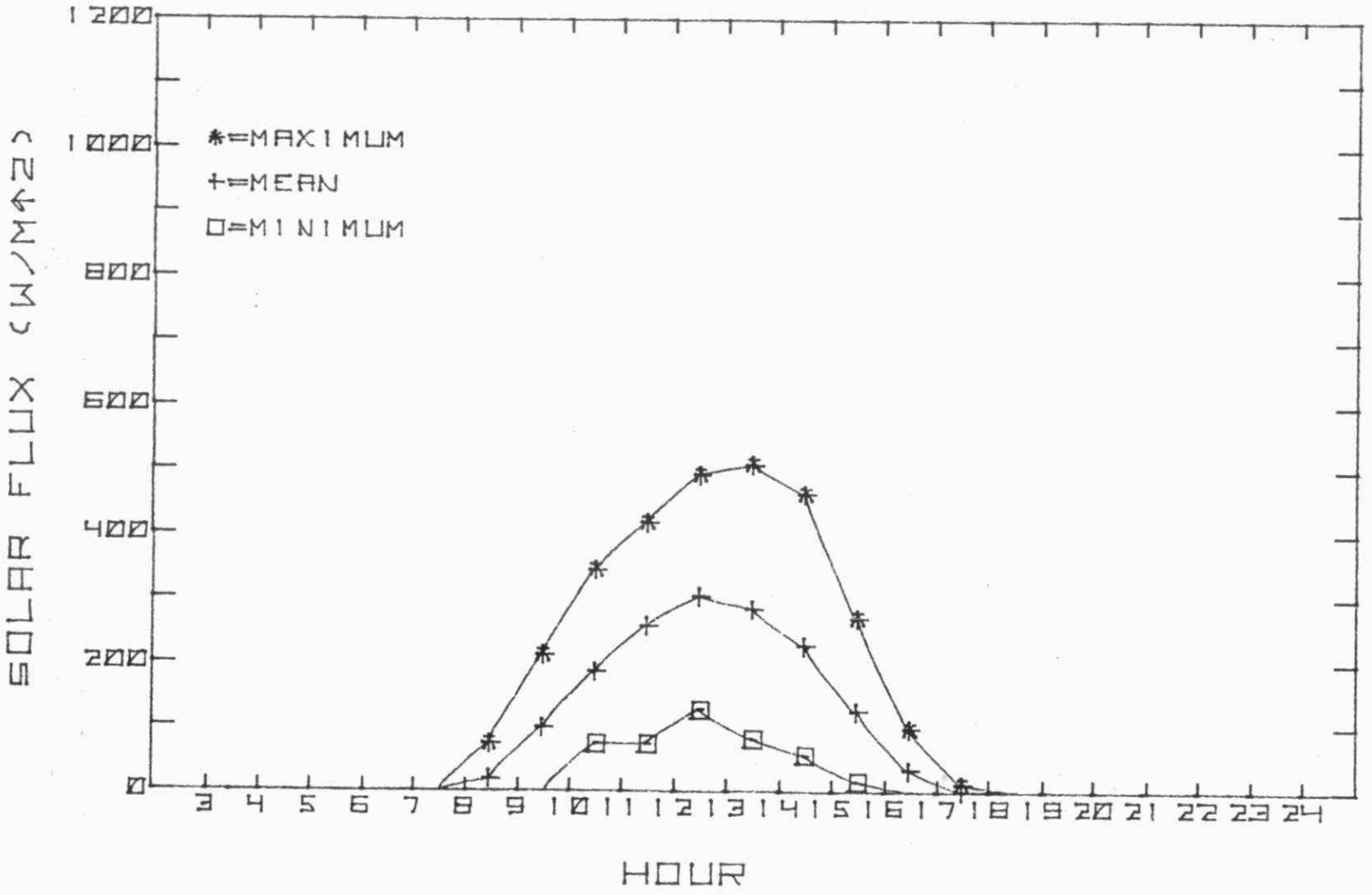


FIGURE 39

SOLAR FLUX - JANUARY 1979

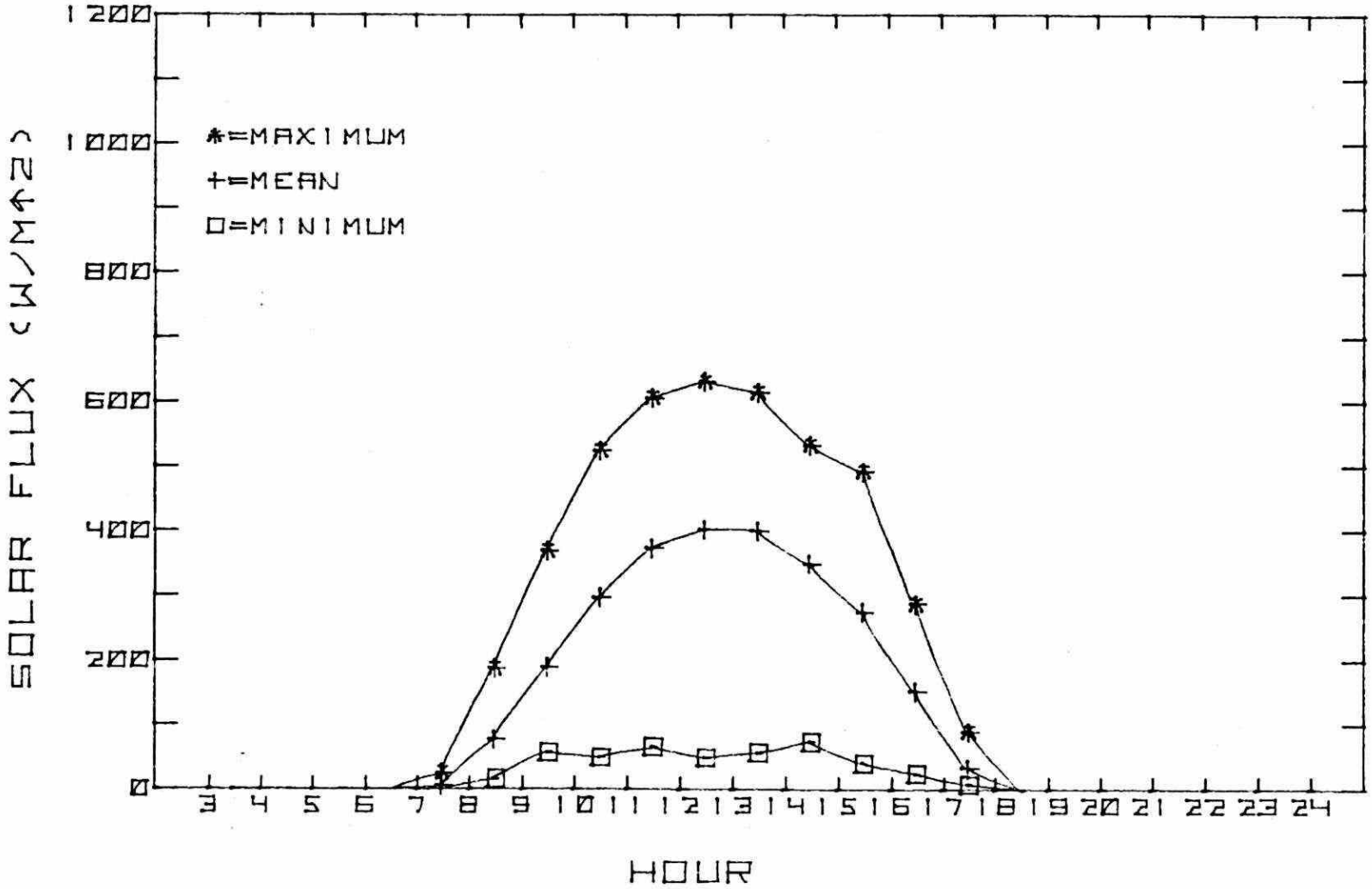


FIGURE 40

SOLAR FLUX - FEBRUARY 1979

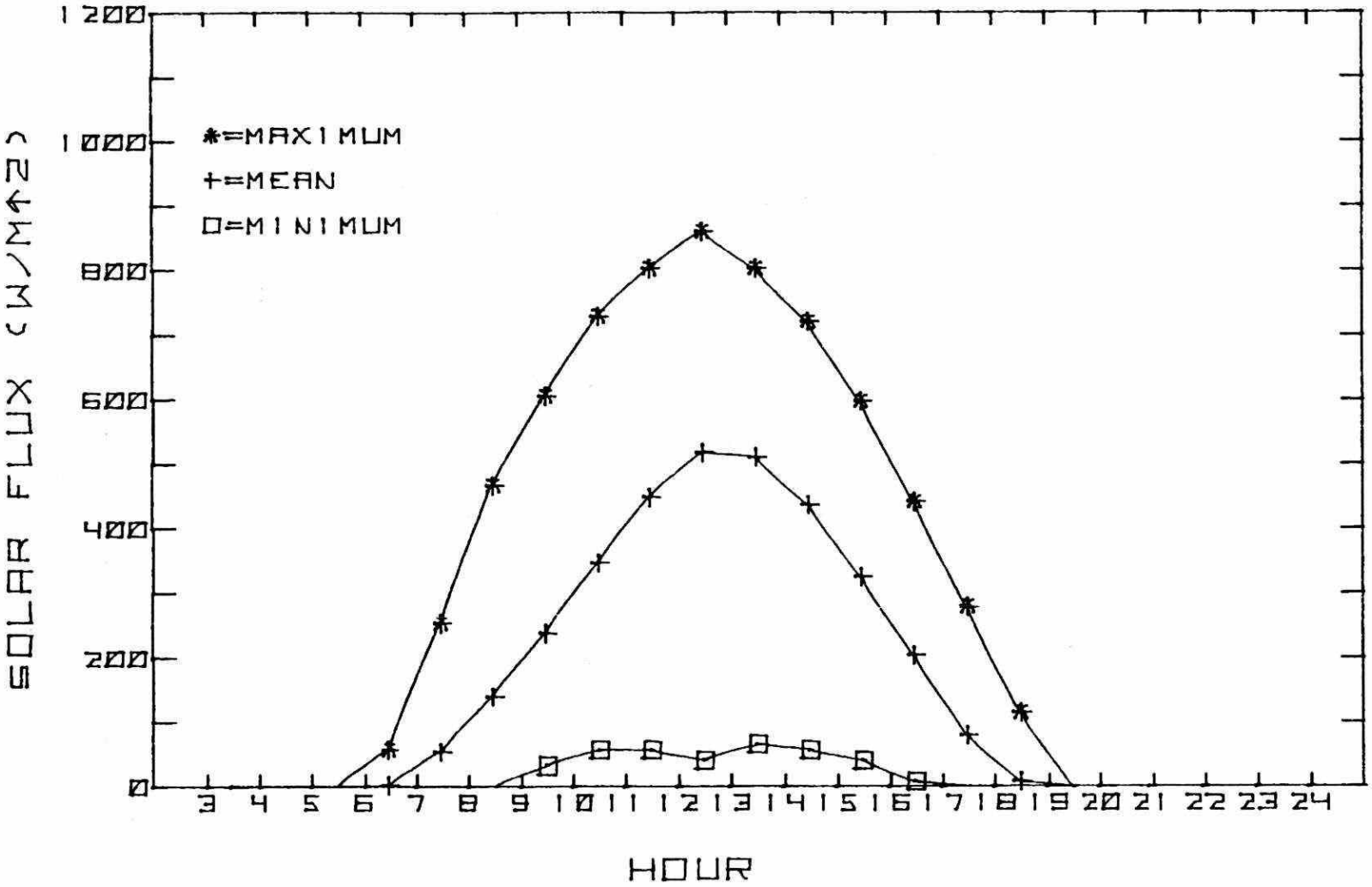


FIGURE 41

SOLAR FLUX - MARCH 1979

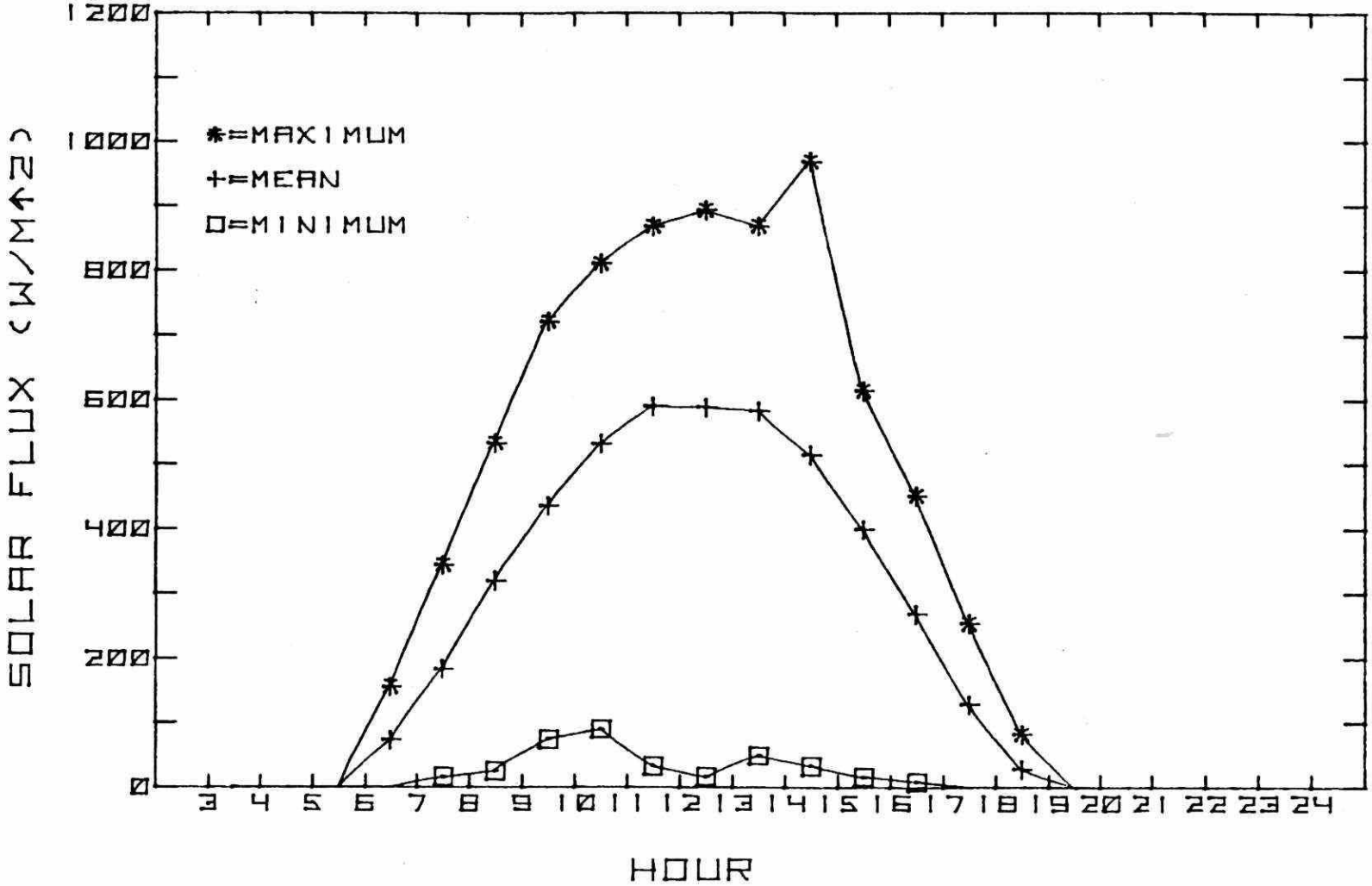


FIGURE 42

SOLAR FLUX - APRIL 1979

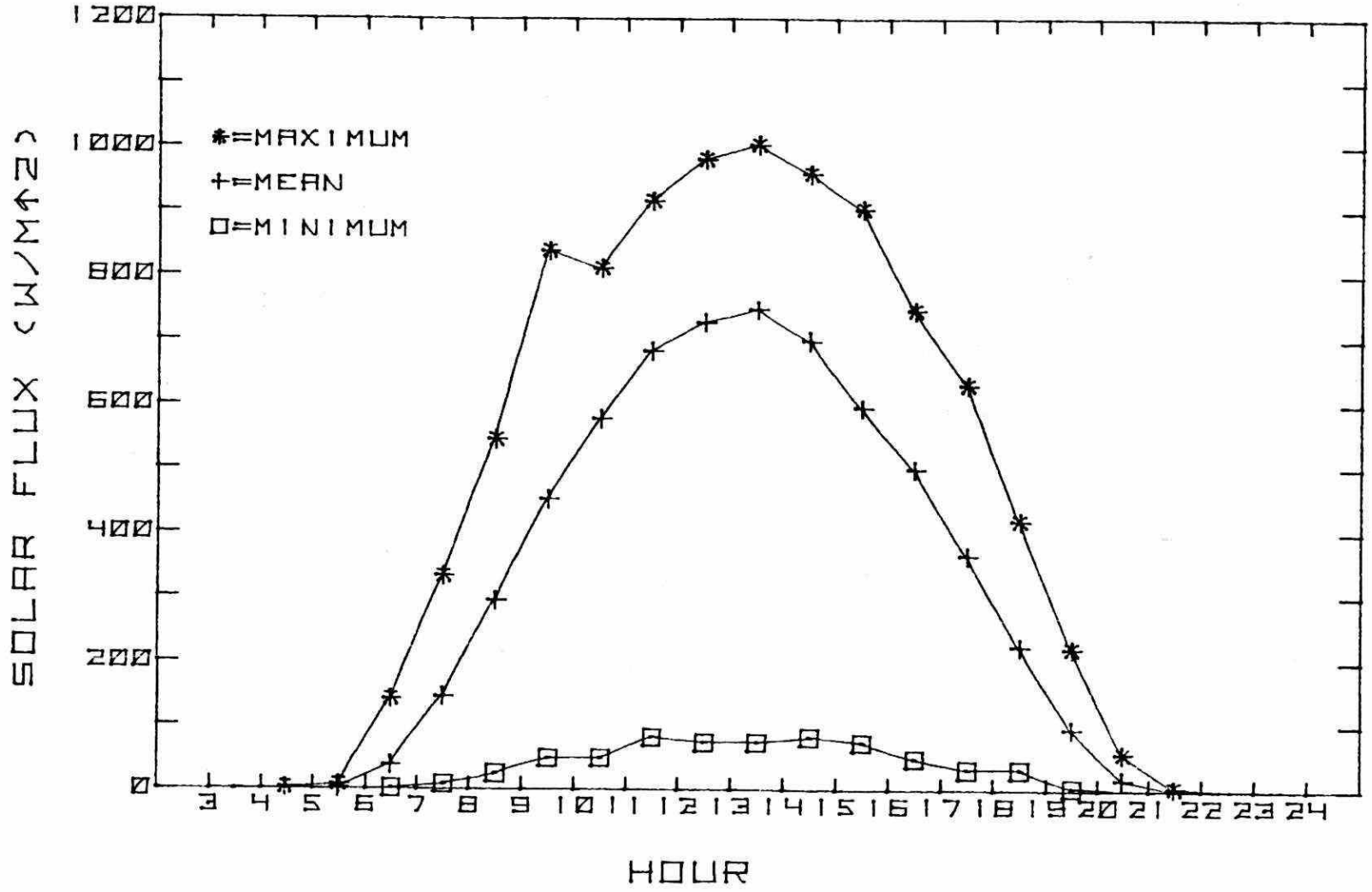


FIGURE 43

SOLAR FLUX - MAY 1977, 1979

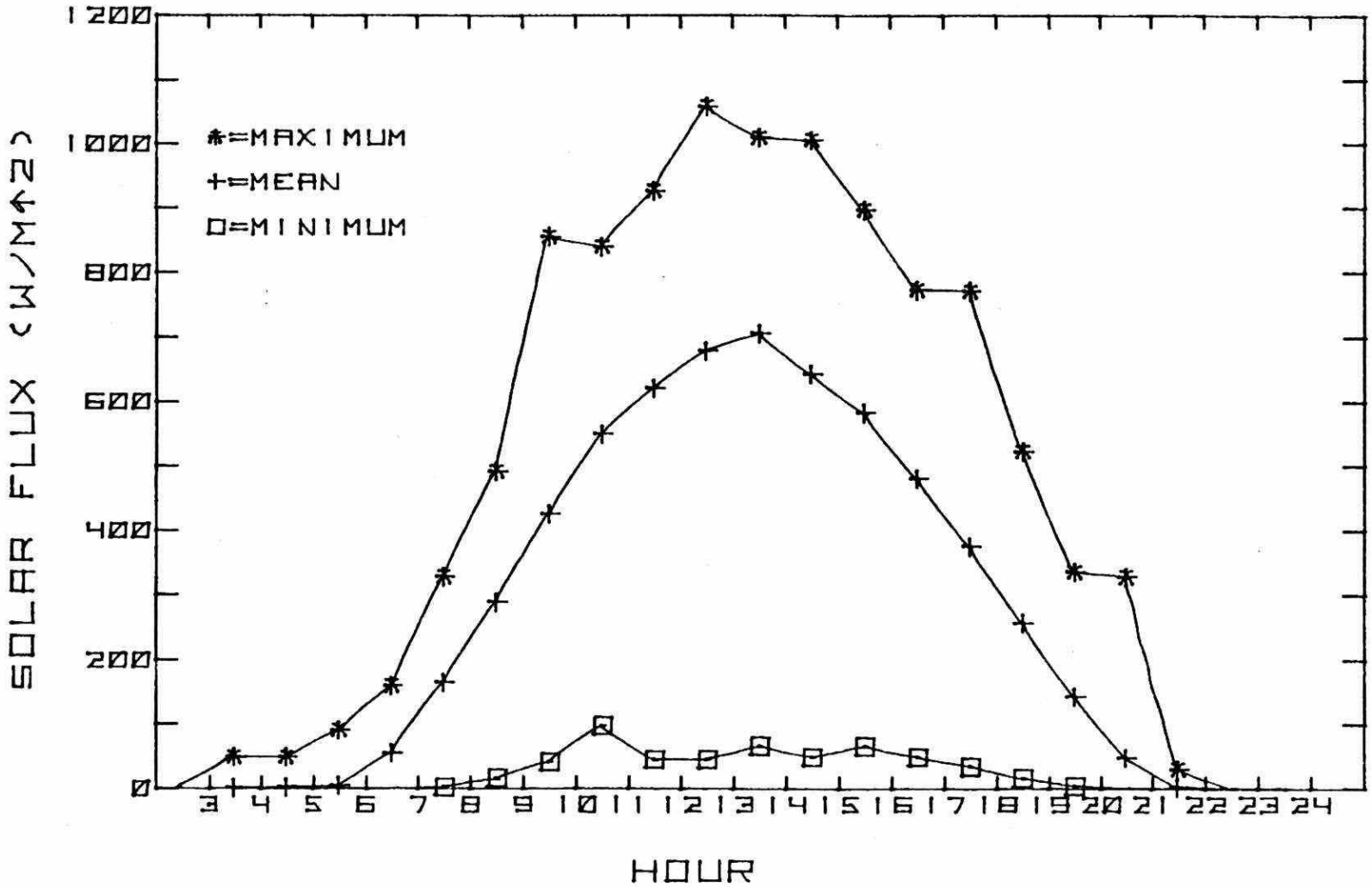


FIGURE 44

SOLAR FLUX - JUNE 1977, 1978, 1979

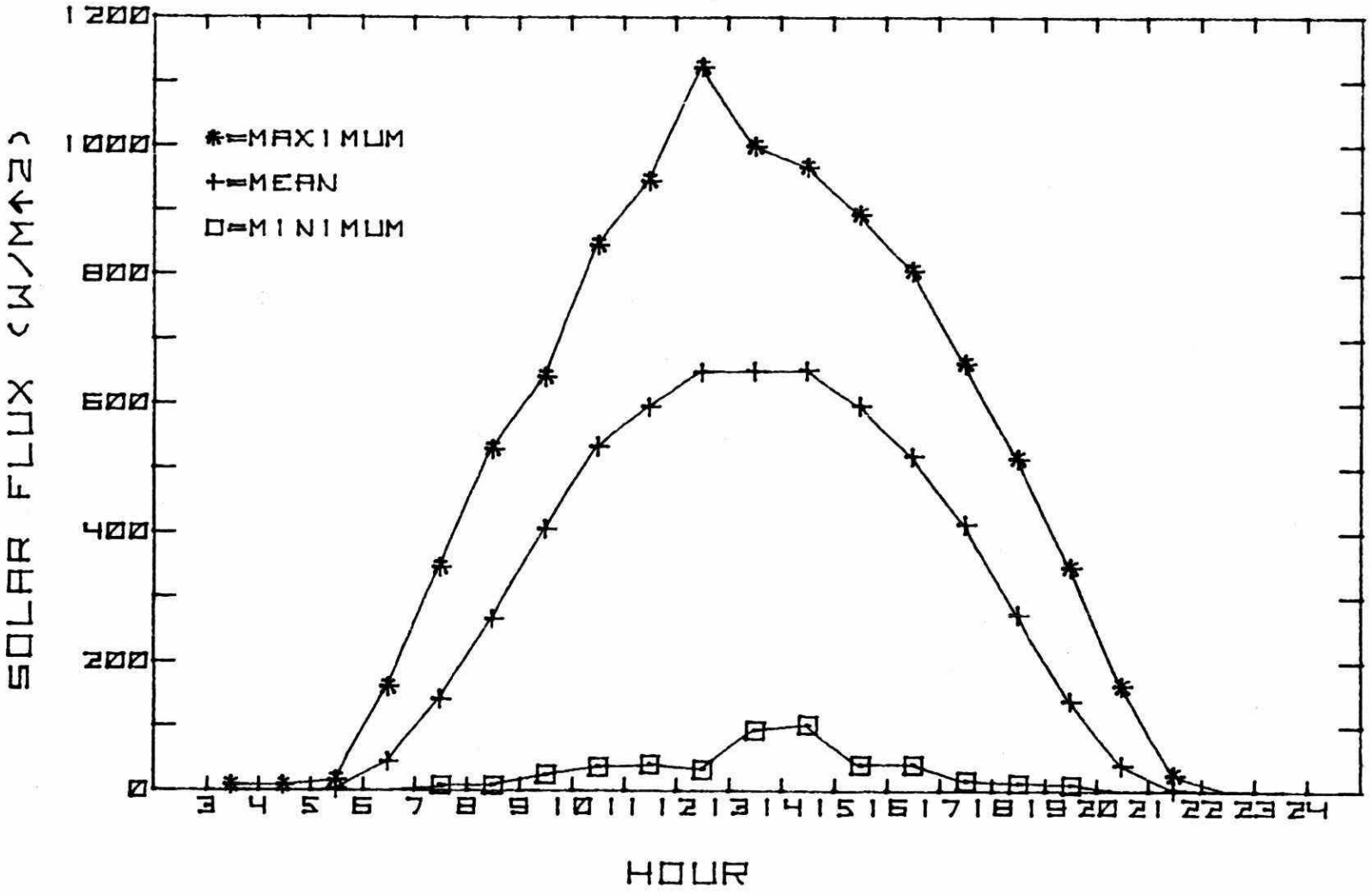


FIGURE 45

SOLAR FLUX - JULY 1977, 1978, 1979

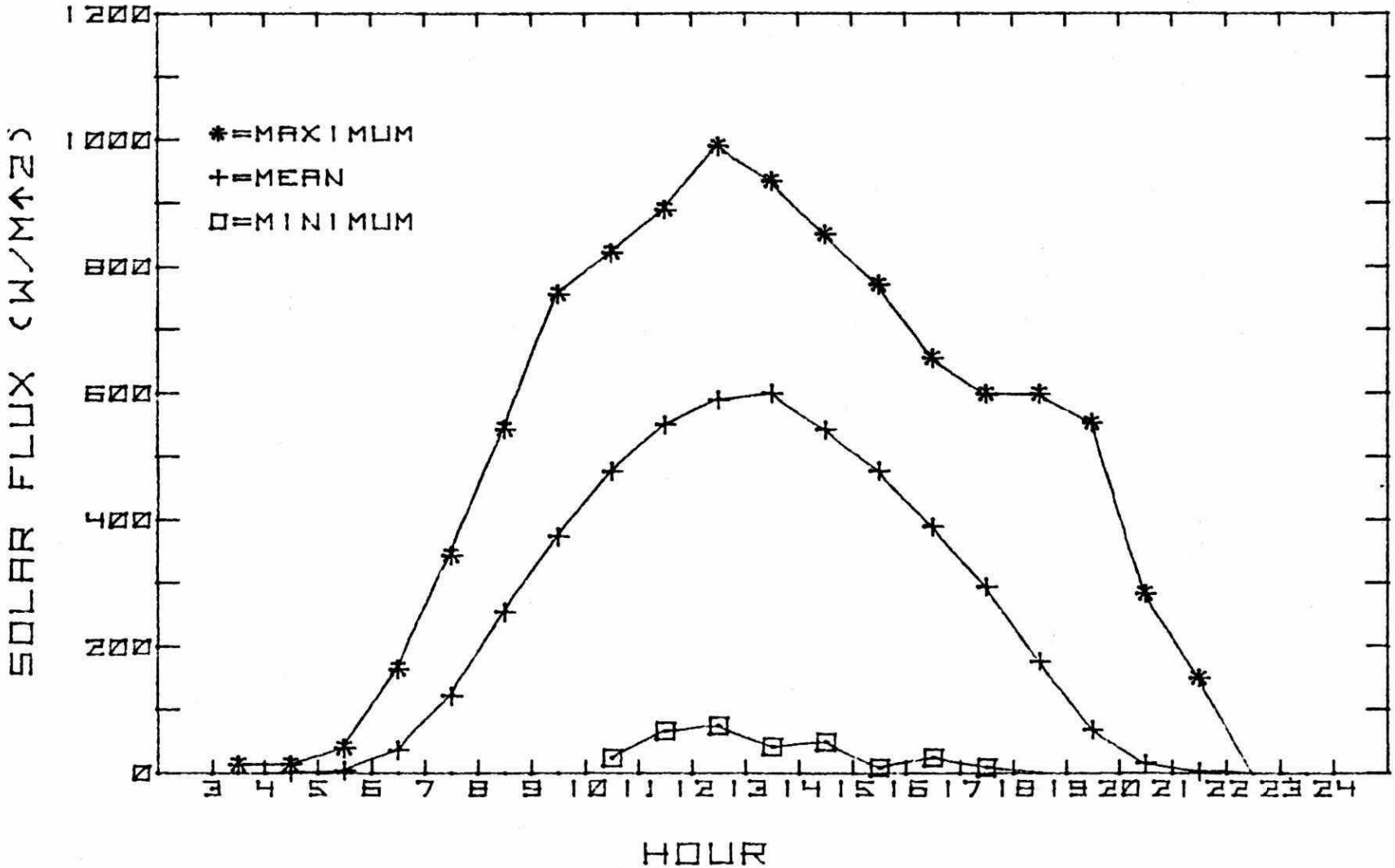


FIGURE 46

SOLAR FLUX - AUGUST 1977, 1978, 1979

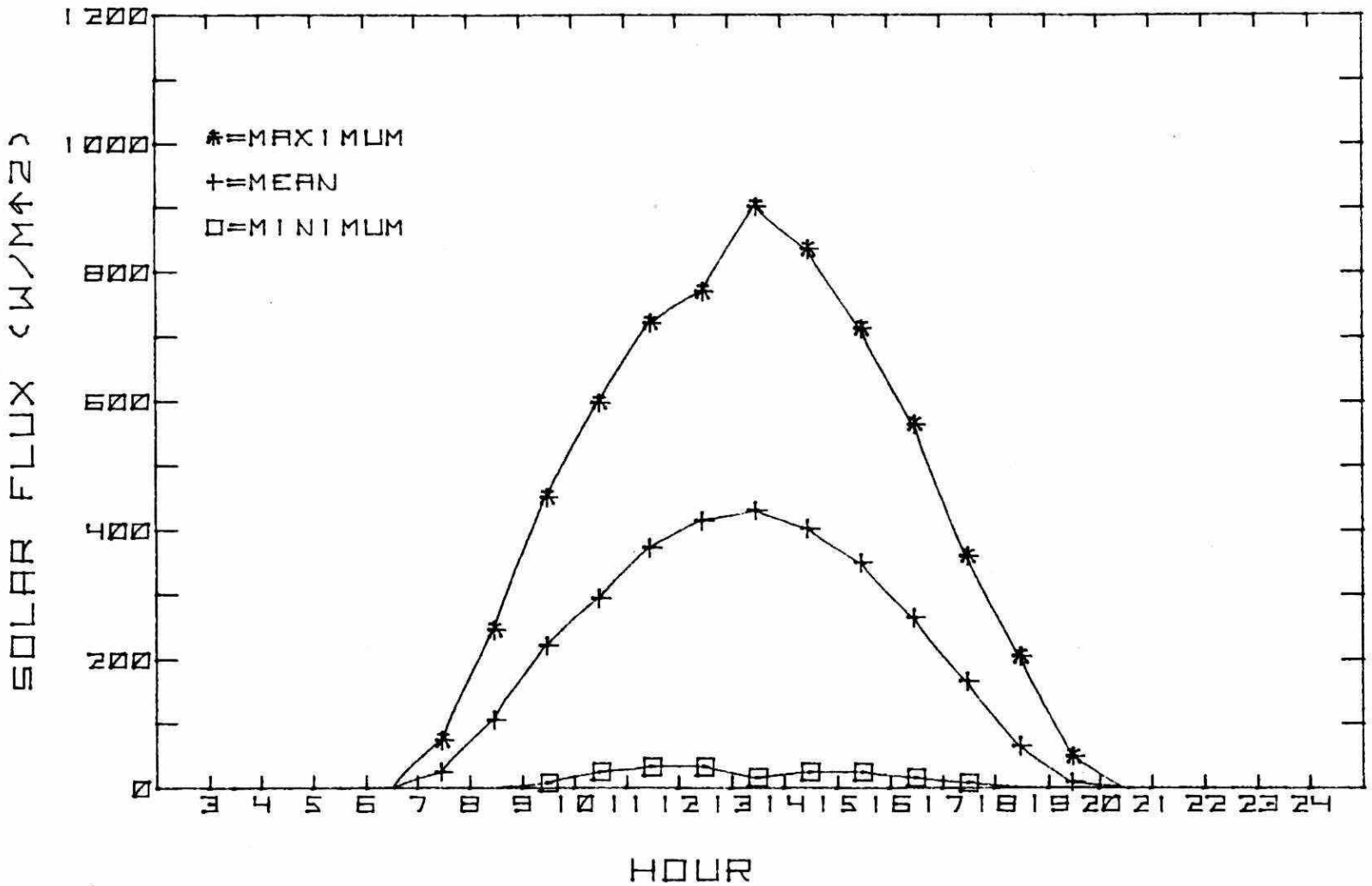


FIGURE 47

SOLAR FLUX - SEPTEMBER 1978

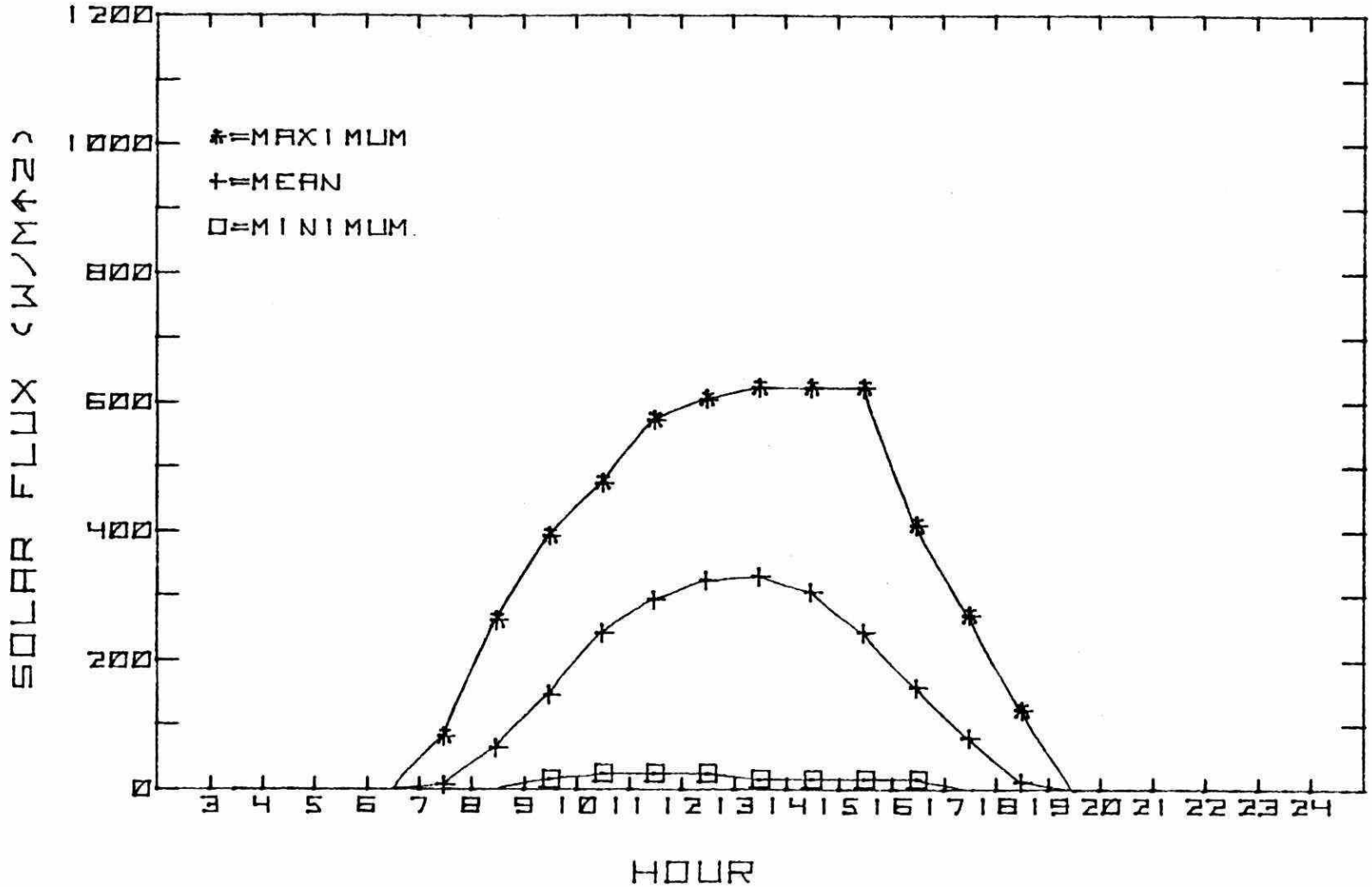


FIGURE 48

SOLAR FLUX - OCTOBER 1978

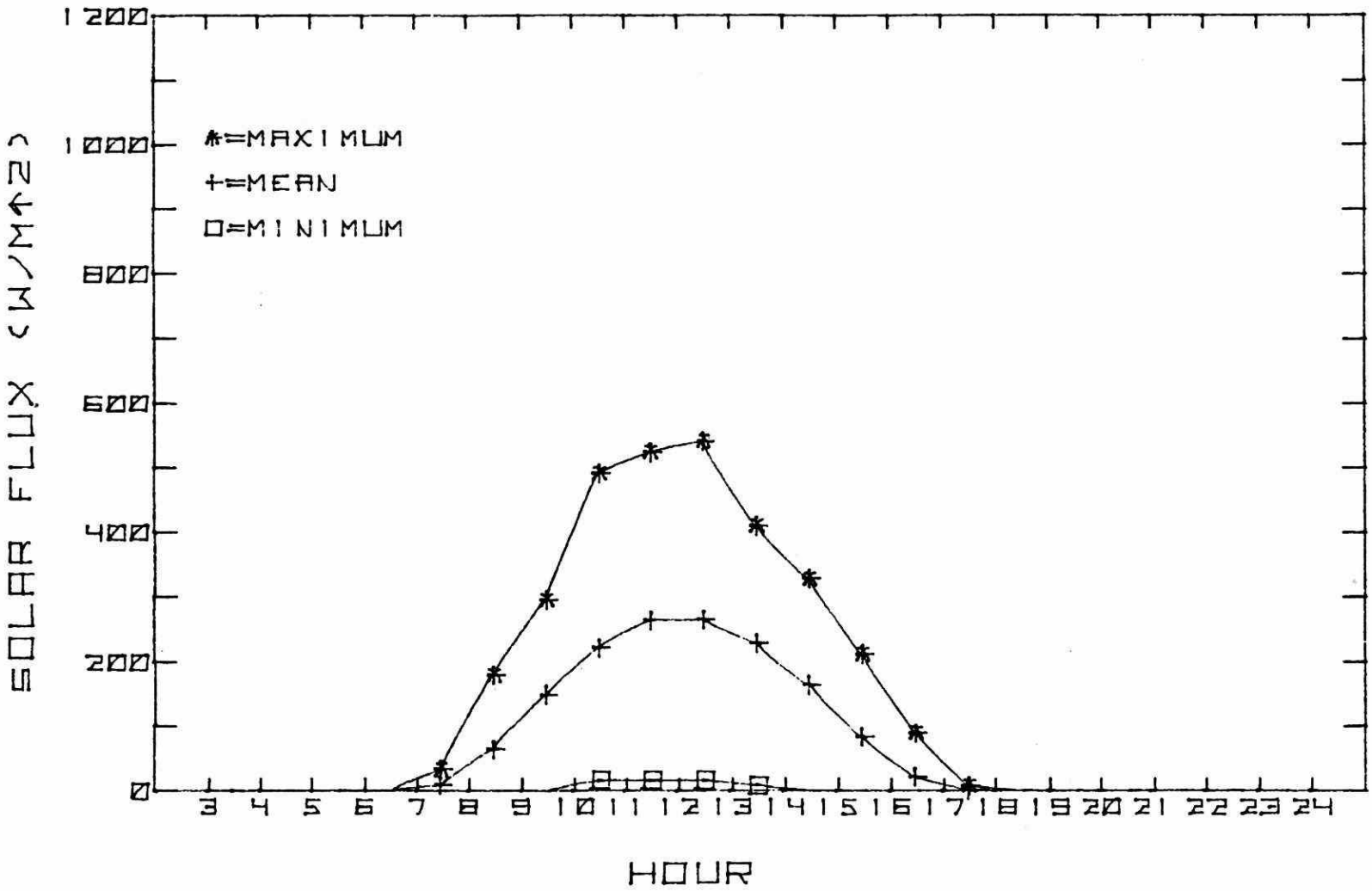


FIGURE 49

SOLAR FLUX - NOVEMBER 1978

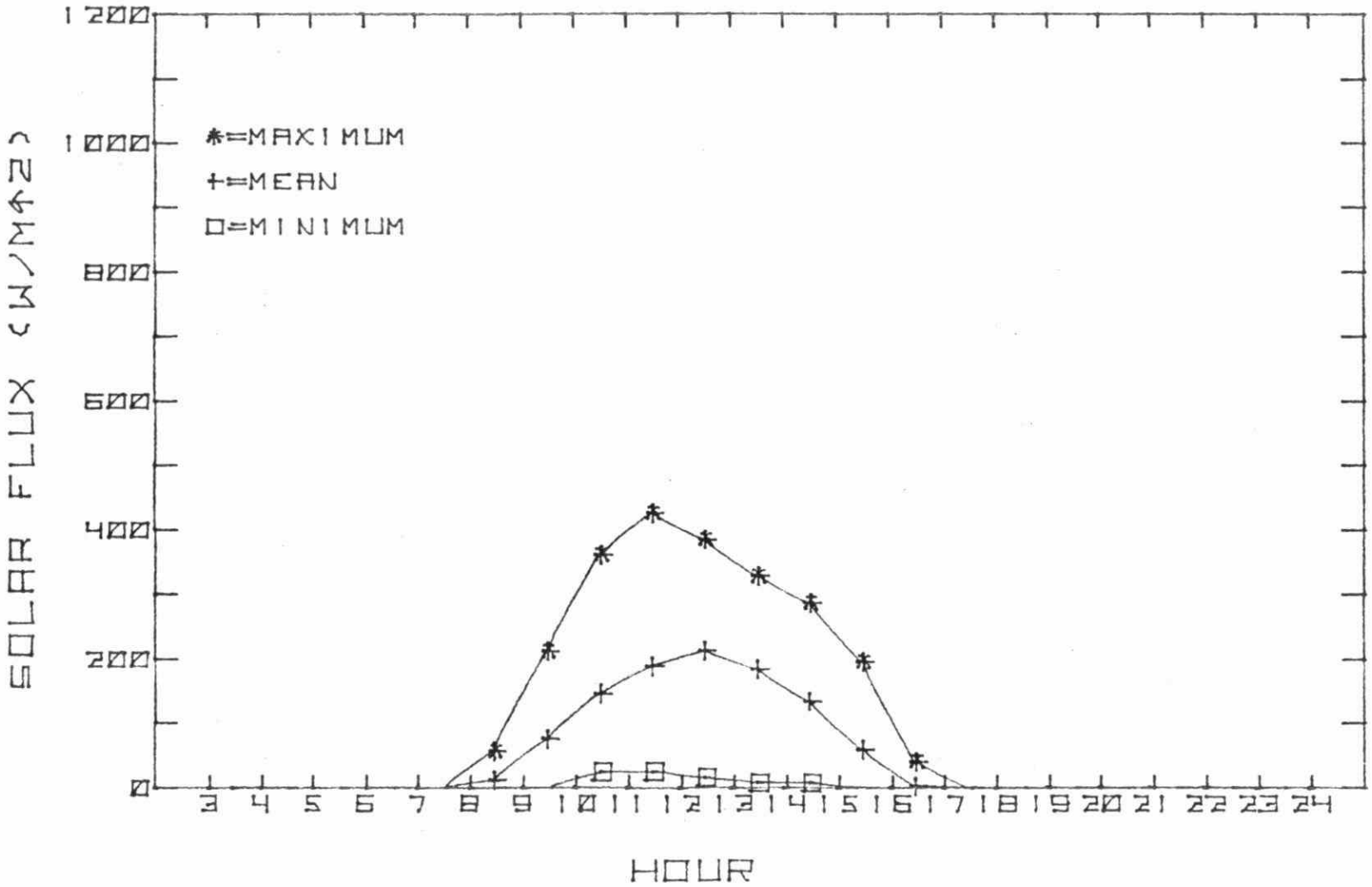


FIGURE 50

SOLAR FLUX - DECEMBER 1978

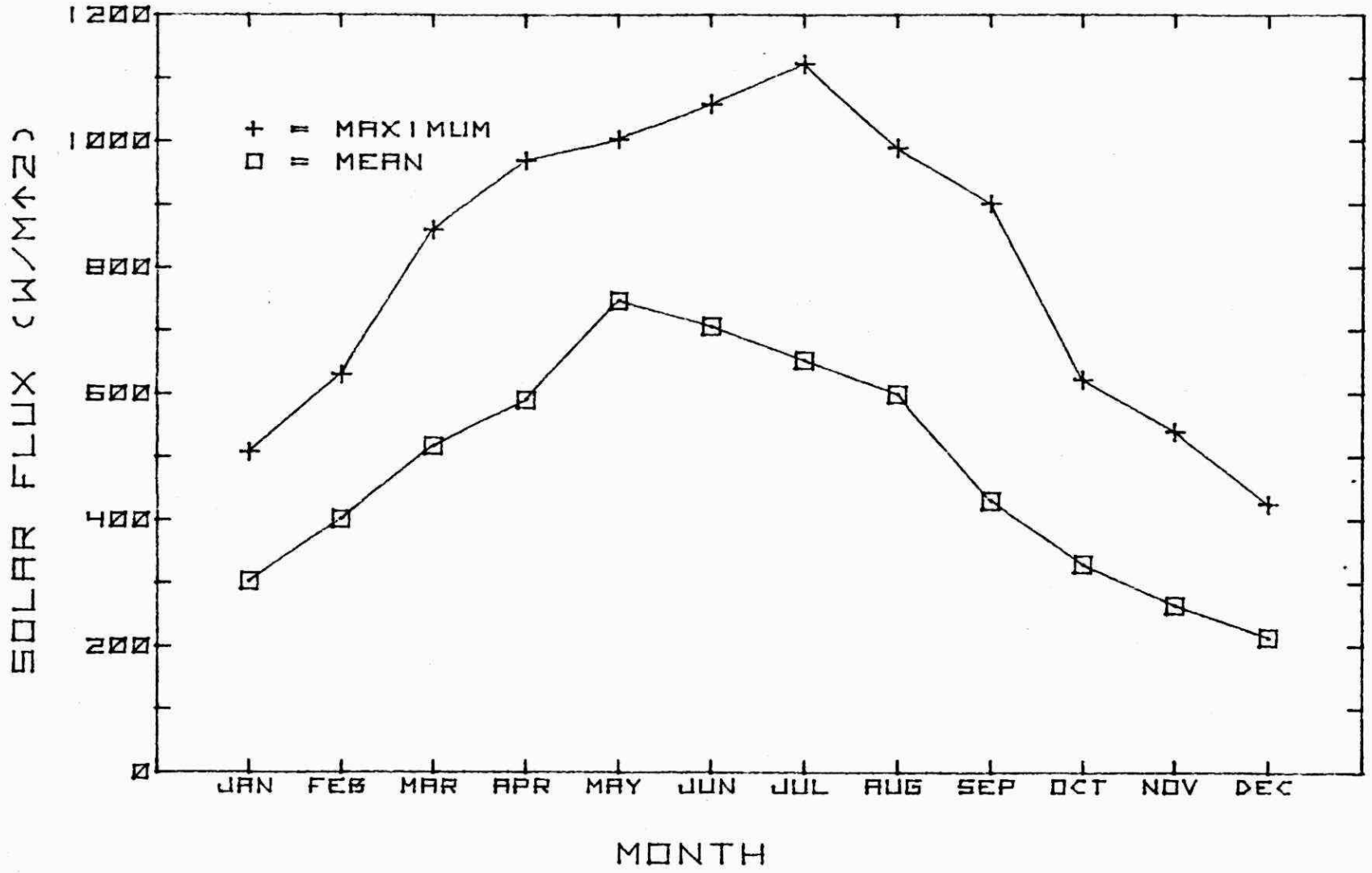


Figure 51

Variation of Solar Radiation Mid-day Maxima and Means

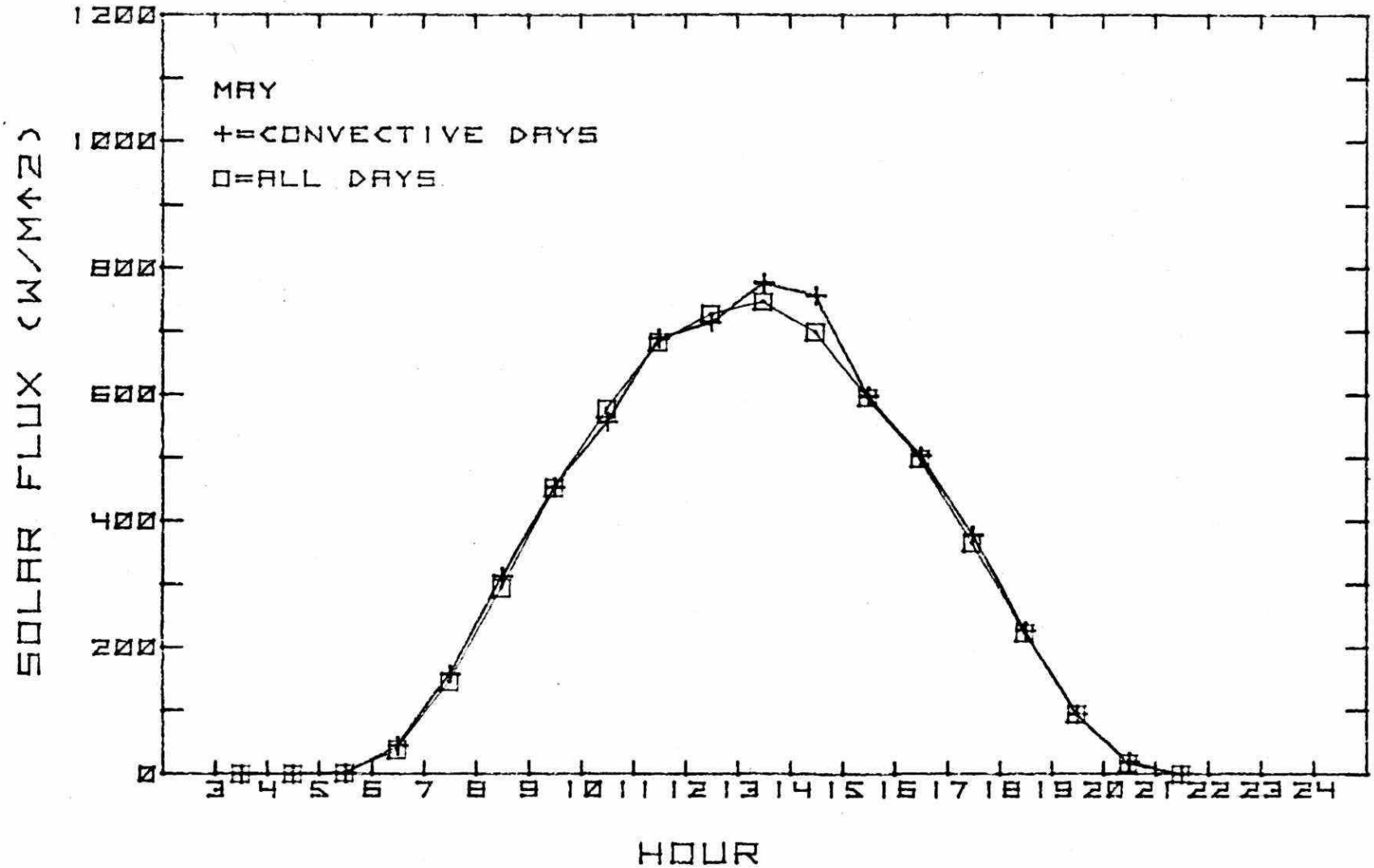


FIGURE 52

COMPARISON OF MEAN SOLAR RADIATION WITH MEAN RADIATION IN CONVECTIVE PERIODS

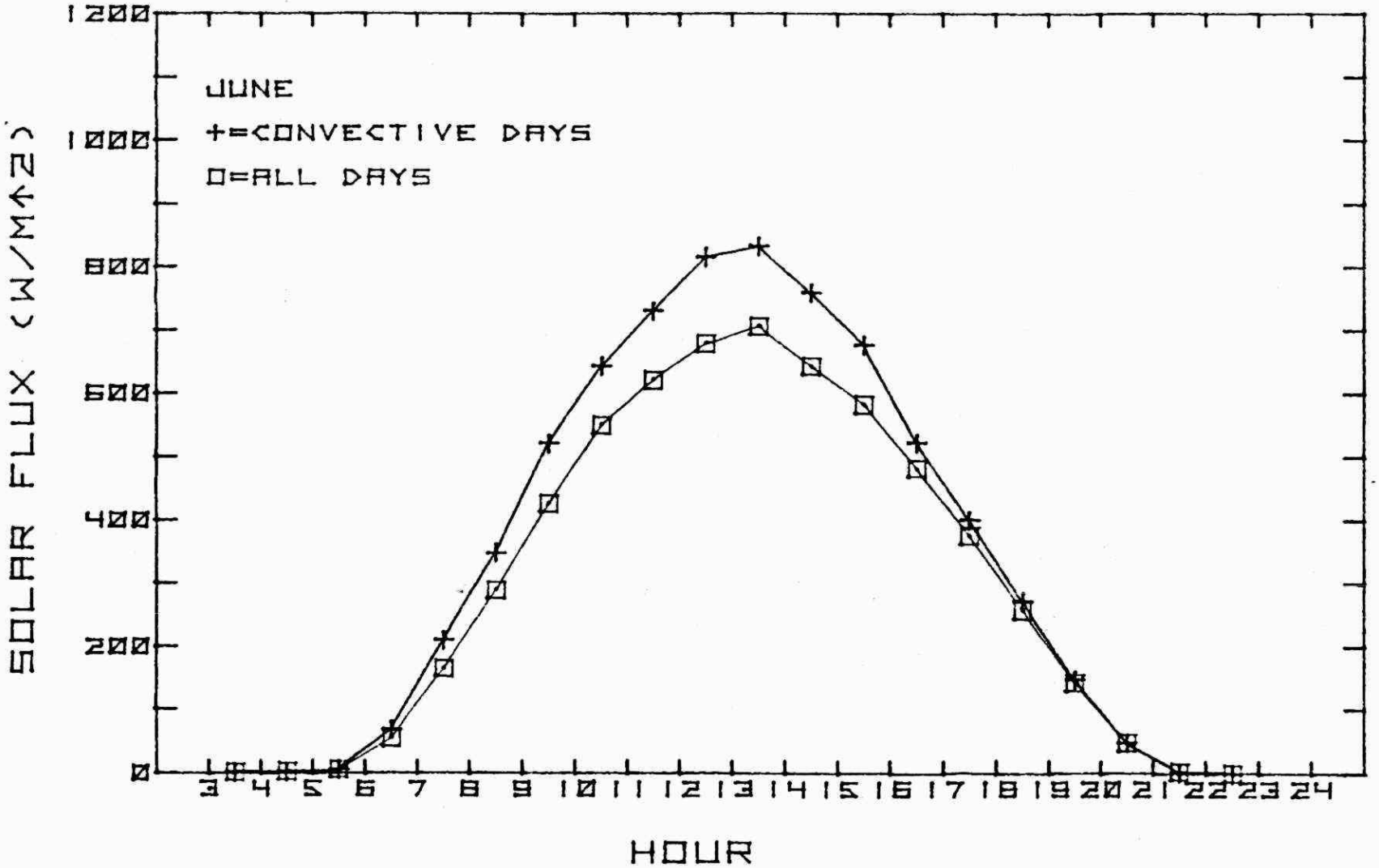


FIGURE 53

COMPARISON OF MEAN SOLAR RADIATION WITH MEAN RADIATION IN CONVECTIVE PERIODS

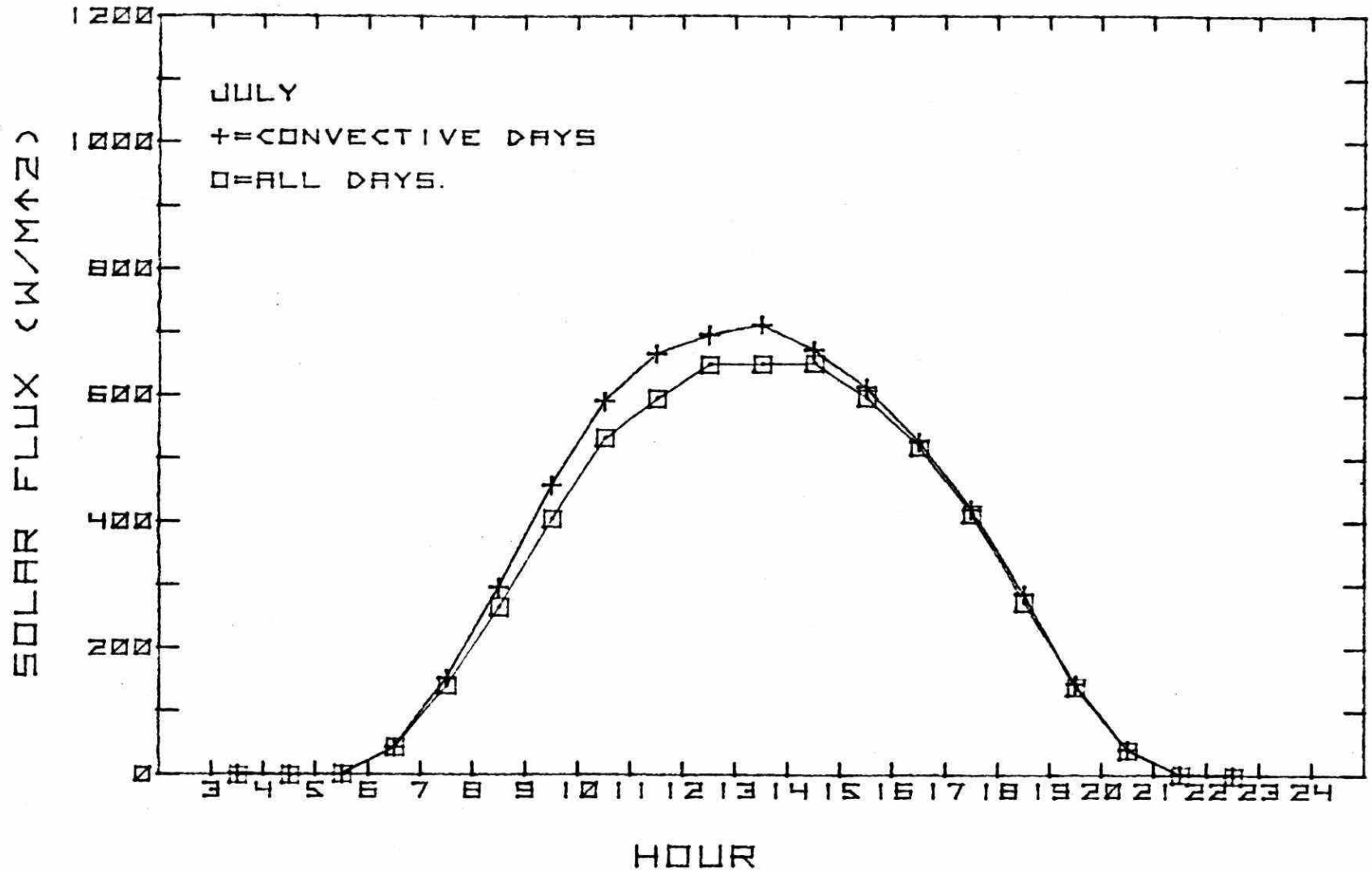


FIGURE 54

COMPARISON OF MEAN SOLAR RADIATION WITH MEAN RADIATION IN CONVECTIVE PERIODS

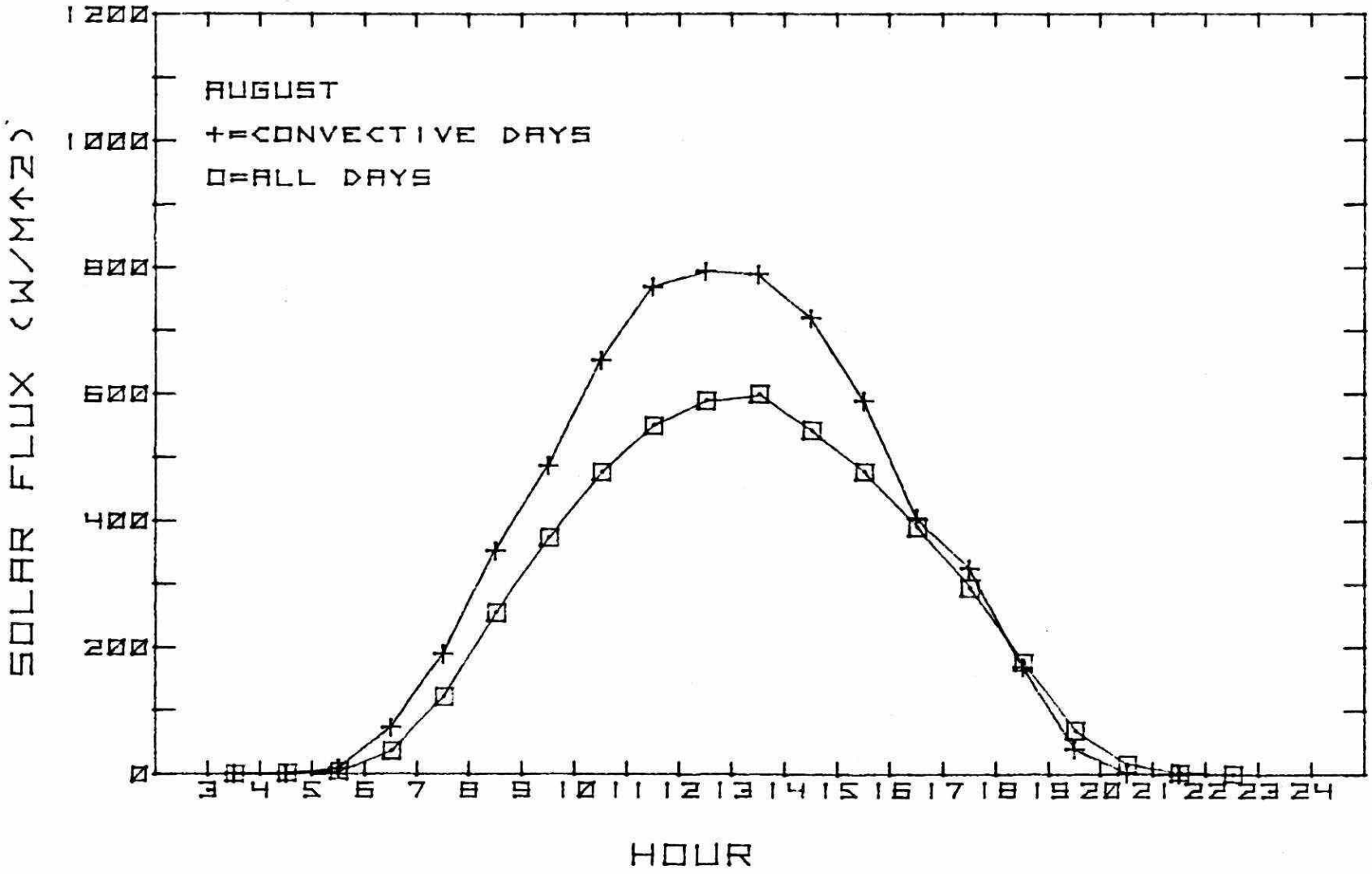


FIGURE 55

COMPARISON OF MEAN SOLAR RADIATION WITH MEAN RADIATION IN CONVECTIVE PERIODS

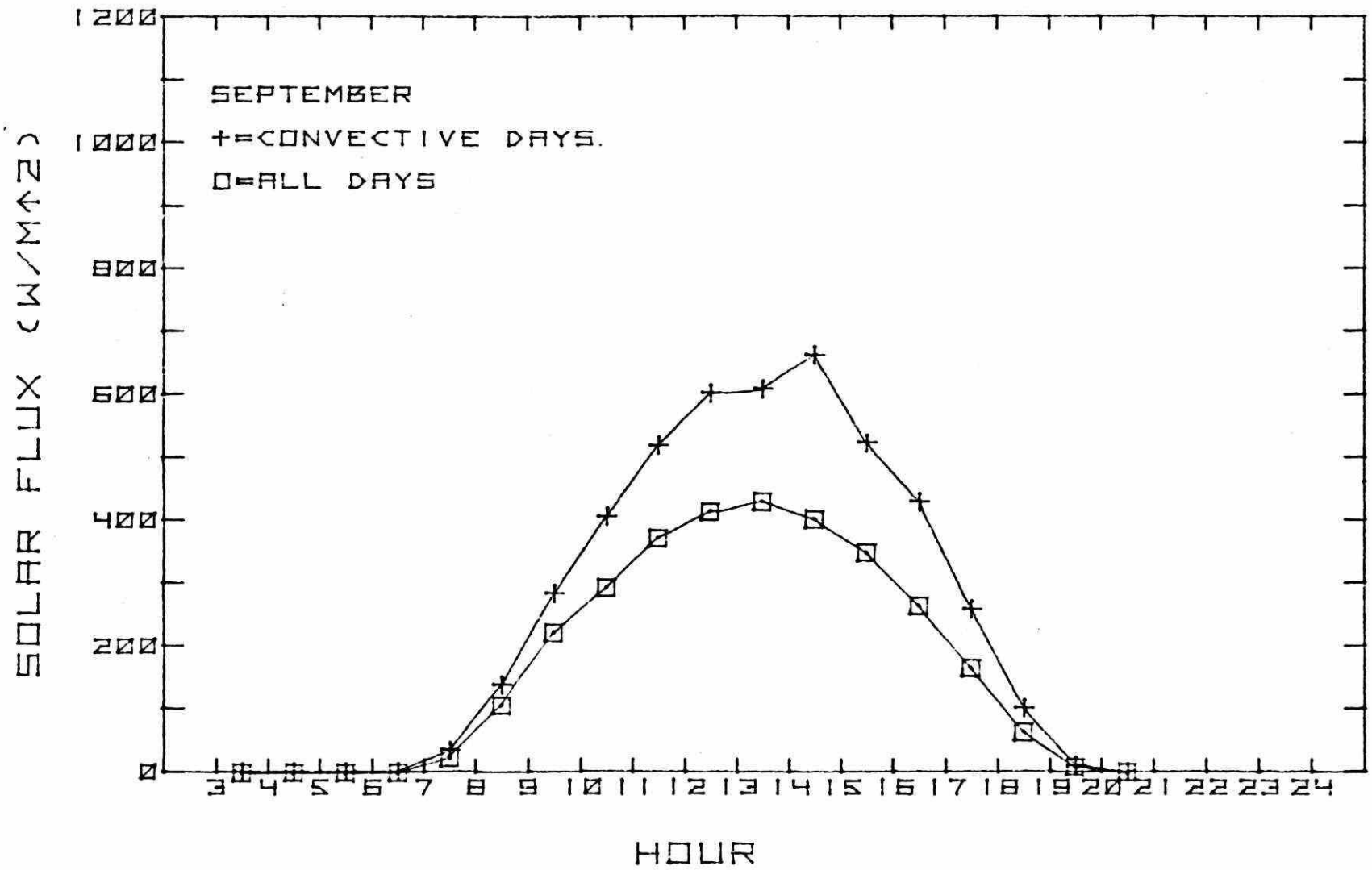


FIGURE 56

COMPARISON OF MEAN SOLR RADIATION WITH MEAN RADIATION IN CONVECTIVE PERIODS

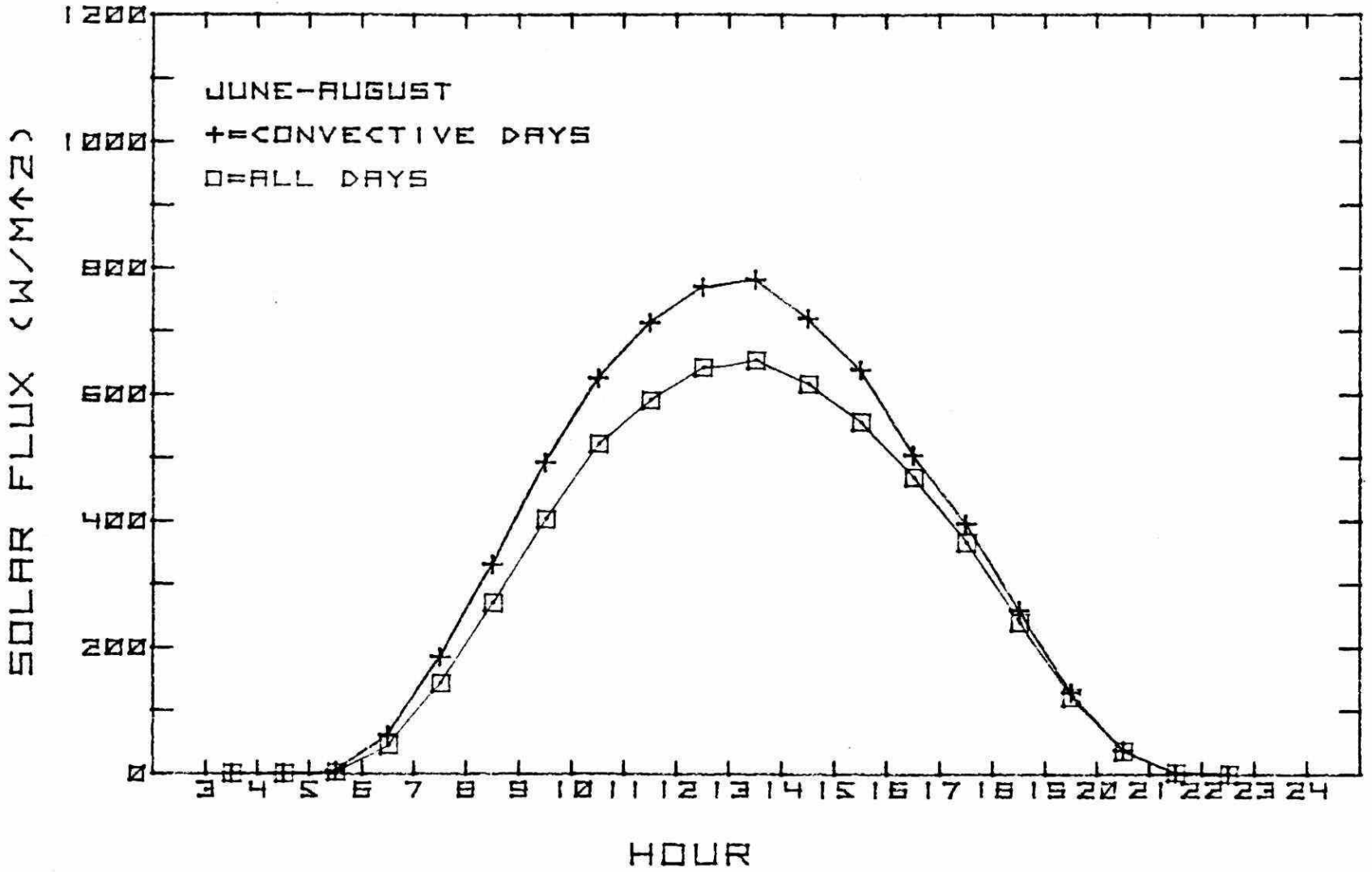


FIGURE 57

COMPARISON OF MEAN SOLAR RADIATION WITH MEAN RADIATION IN CONVECTIVE PERIODS

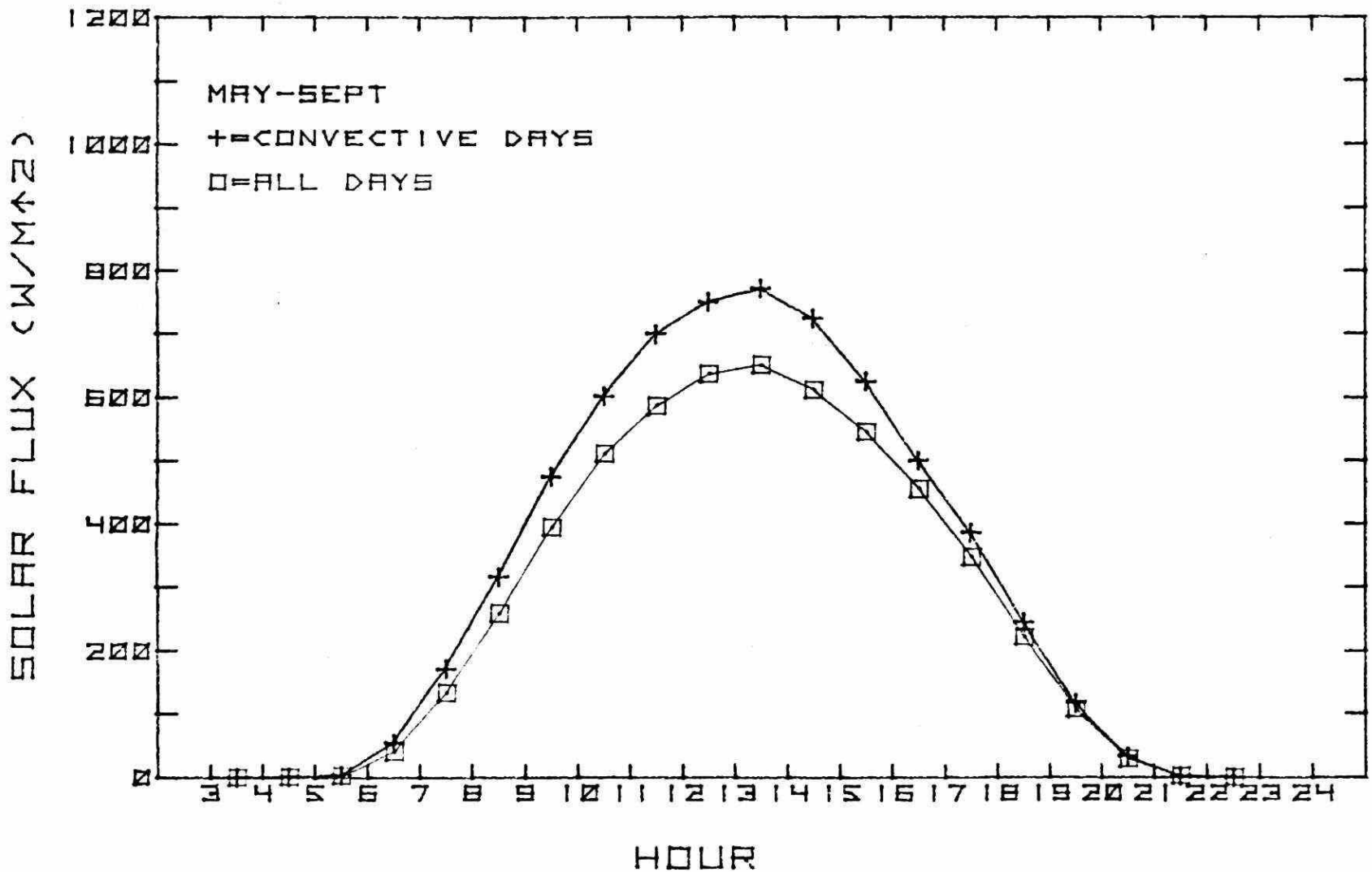


FIGURE 58

COMPARISON OF MEAN SOLAR RADIATION WITH MEAN RADIATION IN CONVECTIVE PERIODS

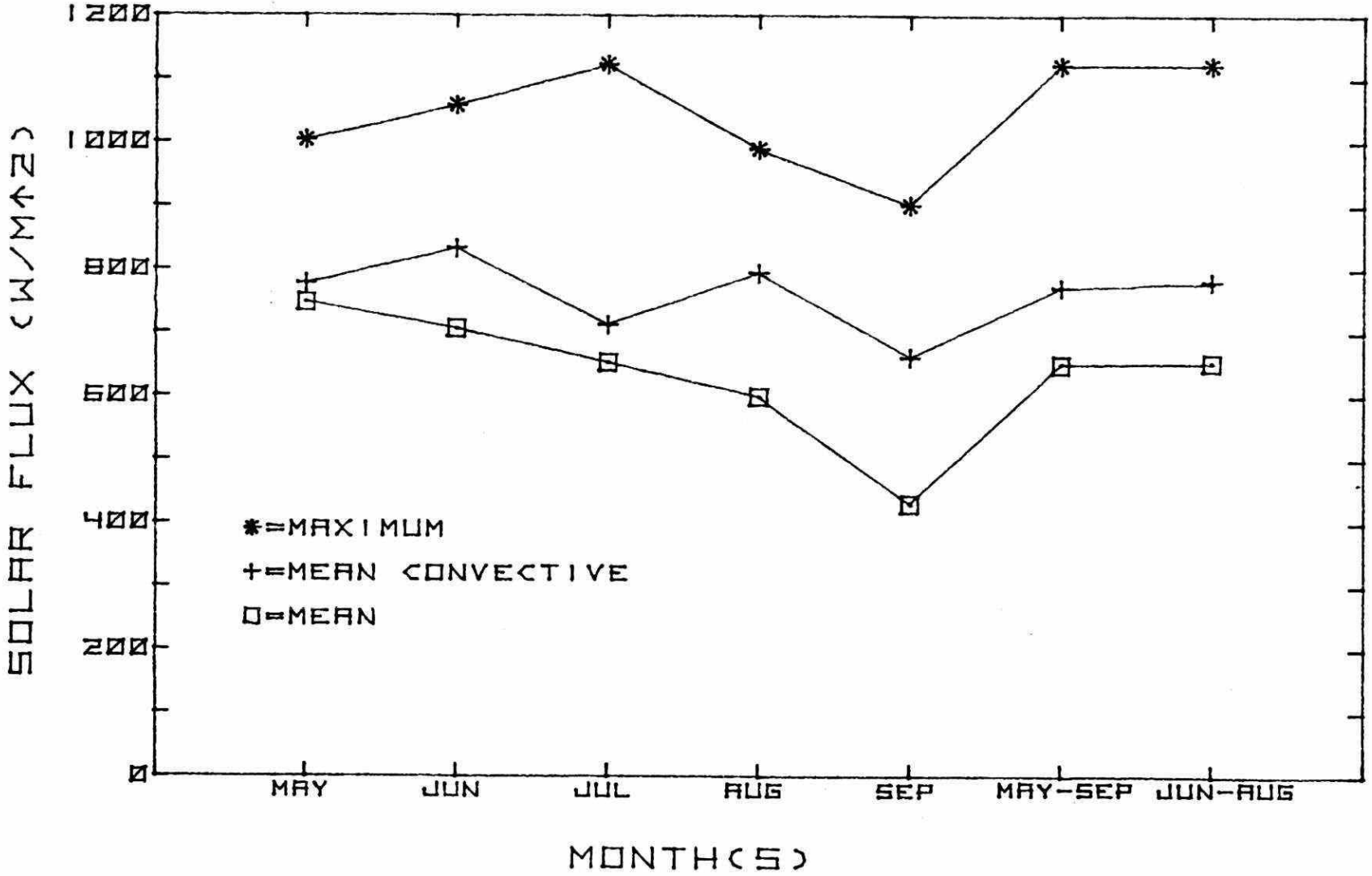


Figure 59: Monthly Mid-day Solar Flux Data

APPENDIX I

Calculation of Potential Temperature

Definition: $$\theta = T\left(\frac{1000}{P}\right)^{R/C_p} \tag{A-1}$$

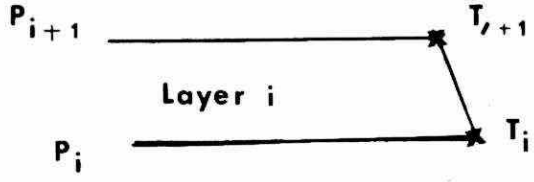
From the minisonde flights, T is known as a function of height but P is not. Since it is required for the calculation of θ, it must be found functionally. This can be done by using the hydrostatic equation and the perfect gas law, i.e.,

$$\frac{dP}{dZ} = -\rho g \quad \text{where} \quad \rho = P/RT \tag{A2}$$

$$\frac{dP}{dZ} = \frac{Pg}{RT} \tag{A3}$$

$$\frac{dP}{P} = -\frac{g}{RT}\,dZ \tag{A4}$$

If one considers the format of the minisonde data, i.e., $T=f(Z)$ measured at 15 second intervals, then the atmosphere can be represented as a series of layers. Each layer has a depth determined by the rise rate of the balloon and is considered to have a linear temperature change with height, see Figure A1



In layer i , $T_z = T_i + \gamma_z$ where $\gamma = \frac{T_{i+1} - T_i}{\Delta Z_i}$

Equation (4) can then be written:

$$\ell n \left(\frac{P_{i+1}}{P_i}\right) = \frac{-g}{R}\int_{Z_i}^{Z_{i+1}} \frac{dz}{T_i + \gamma z} \tag{A5}$$

$$= \frac{-g}{R\gamma} \ell n \left(\frac{T_{i+1}}{T_i}\right) \tag{A6}$$

$$= \frac{-g\Delta Z_i}{R(T_{i+1} - T_i)} \ell n \left(\frac{T_{i+1}}{T_i}\right) \tag{A7}$$

$$= \ell n \left(\frac{T_{i+1}}{T_i}\right)^{-g\Delta Z_i / R(T_{i+1} - T_i)} \tag{A8}$$

$$\therefore P_{i+1} = P_i \left[\frac{T_{i+1}}{T_i}\right]^{g\Delta Z / R(T_i - T_{i+1})} \tag{A9}$$

Using equation (A-9), the pressure at each temperature measurement

interval can be determined. This value of **P** can then be substituted back into equation (1) to determine the potential temperature at each height. All that is required for this calculation is a knowledge of the ground level pressure.

The following procedure changes the ambient temperature profile to potential temperature within the analysis program. Figure A2 illustrates the situation.

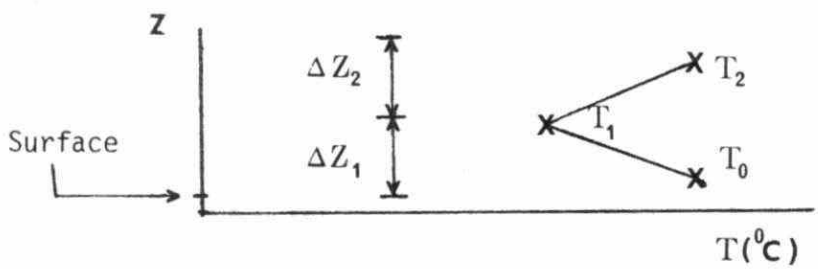


Fig. A-2

1. Store temperature and height data for each 15 second interval of the balloon ascent.

2. Calculate the surface level potential temperature as:

$$\theta_o = T_0 \left(\frac{1000}{P_0}\right)^{R/C_p} \qquad \text{(A-10)}$$

3. Calculate the pressure, P_{i+1} at each temperature point in the profile, T_{i+1} using Equation (9), i.e.;

$$P_{i+1} = P_i \left[\frac{T_{i+1}}{T_i}\right]^{g\Delta Z/R(T_i - T_{i+1})}$$

where i = 0, N and **0** = surface (A-11)

4. Calculate the potential temperature at each point i using Equation (A-11).

$$\Theta_{i+1} = T_{i+1} \left[\frac{1000}{P_{i+1}}\right]^{R/C_p}$$

Note: Where ground level pressures at the time of balloon release were not available, they were estimated using Sudbury Airport pressure data accounting for the difference in elevation.

Appendix 2

SES Pilot Balloon - Minisonde Analysis Program

(for Hewlett-Packard 9825)

```
0: dim A[34],B[34],C[34],D[34],E[34,2],X[34],L[34],F$[30],G$[30],I,S,P,
N,Q,R
1: dim U[34],V[34],J[34],Q[34],R[34]
2: dim U$[3],W$[3],Z$[3],M[34],N[34],O[34],P[34]
3: dim V$[3],O$[3],I$[12],H$[6]
4: "StArT":dsp "temp only? enter-99 for baseline";wait 2000
5: ent "BASELINE #?",r0,"GROUND PLANE ANGLE?",r1,"MET. DATA?",F$[1,30]
6: ent "PLUME DATA?",G$[1,30],"DAY?",r64,"MONTH?",r65,"YEAR?",r66
7: ent "TIME OF RUN?",r67,"output?",O$
8: ent "PRESSURE?",Q,"REL HUMIDITY?",R
9: if r0=1; 385.9→r37; 68.23→r33; 259.15→r30; jmp 5
10: if r0=2; 300.4→r37; 166.23→r33; 259.15→r30; jmp 4
11: if r0=3; 343.96→r37; 237.3→r33; 256→r30; jmp 3
12: if r0=4; 325.84→r37; 154.5→r33; 256→r30; jmp 2
13: ort "base",r0; ent "Base length?",r37,"Bearing?",r38; 256→r30
14: if r0=-99; sfg 8
15: fmt 0,50x,"ONTARIO MINISTRY OF THE ENVIRONMENT",/
16: fmt 1,54x,"Sudbury Environmental Study",2/
17: fmt 9,10x,f2.0,"/",f2.0,"/",f4.0,15x,f4.0,4/
18: fmt 2,3x,"Time",5x,"Azimuth 1",3x,"Elevation 1",4x,"Azimuth 2"
19: fmt 3,51x,"Elevation 2",6x,"Temp.",6x,"Mid-Point Temp."
20: fmt 4,3x,"(min)",4x,"(degrees)",4x,"(degrees)",5x,"(degrees)"
21: fmt 5,52x,"(degrees)",4x,"(degrees C)",5x,"(degrees C)"
22: fmt 6,5x,"PRESSURE",3x,f6.1,10x,"REL. HUMIDITY",3x,f4.0,"%",3/
23: fmt 7,5x,"Met. Data",c36,2/,5x,"Plume Data",c36,2/
24: fmt 8,44x,"Baseline ",f2.0,5x,"Bearing ",f7.2,5x,"Length ",f7.2,3/
25: dsp "set printer to .5, press CONT";sto
26: wtb 6,27,84; wtb 6,27,70,int(1056/64),int(1056)
27: wtb 6,27,76,int(960/64),int(960); wrt 6; wrt 6.1
28: wrt 6.9,r64,r65,r66,r67; wtb 6,27,10; wtb 6,27,10; wtb 6,27,10
29: if flg8=0; wrt 6.8,r0,r33,r37
30: wrt 6.7,F$,G$; wrt 6.5,Q,R
31: wrt 6.2; wtb 6,27,10; wrt 6.3; wrt 6.4; wtb 6,27,10; wrt 6.5
32: wtb 6,27,10; for I=1 to 95; wtb 6,95; next I; wtb 6,13; wtb 6,10; wtb 6,1
0
33: fmt 6,1x,f6.1,5x,f7.2,5x,f7.2,7x,f7.2,5x,f7.2,3x,f5.1,10x,f5.1
34: fmt 2,1x,f6.1,5x,f7.2,5x,f7.2,7x,f7.2,5x,f7.2
35: fmt 3,1x,f6.1,5x,f7.2,5x,f7.2,7x,f7.2,5x,f7.2,3x,f5.1
36: fmt 4,1x,f6.1,50x,f5.1,10x,f5.1
37: fmt 0,1x,f6.1,50x,f5.1
38: "sgo":for I=1 to 33
39: if I#1; if flg8; 2^9→r40; jmp 2
40: ent "Azimuth 1?",r40,"Elev 1?",r41,"Azimuth 2?",r42,"Elev 2?",r43
41: ent "Mid-Point Temp.?",r44,"Obs. Point Temp.?",r45
42: r40→A[I]; r41→B[I]; r42→C[I]; r43→D[I]; r44→E[I,1]; r45→E[I,2]
43: "skp":(I-1)/2→r23; if A[I]=2^9 and E[I,2]=99; 0→C[I]; gto "done"
44: if flg8=0; if A[I]=2^9 and E[I,2]#99; sfg 3; I-1→r50
45: if flg8 and I=1; wrt 5,r23,E[I,2]; gto "kne"
46: if flg8; wrt 6.4,r23,E[I,2],E[I,1]; gto "kne"
47: if I=1; wrt 6.3,r23,A[I],B[I],C[I],D[I],E[I,2]; jmp 4
48: if E[I,1]#99; jmp 2
49: wrt 6.2,r23,A[I],B[I],C[I],D[I]; jmp 2
50: wrt 6.6,r23,A[I],B[I],C[I],D[I],E[I,2],E[I,1]
51: "kne":next I
52: "done":I-1→r35→I; if flg3; r50→r35; I→r50; r35→I
53: "six":"yes"→O$; if r35#I; r35→I
```

```
54: fmt 5,2x,"Baseline ",f2.0,5x,"Bearing ",f7.2,5x,"Length ",f7.2,3/
55: if flg2;jto "calc"
56: wto 6,12
57: wrt 6;wrt 6.1;wrt 6.9,r54,r55,r56,r57
58: fmt 1,3x,"Time",7x,"X",10x,"Y",8x,"Height",3x,"Height (MSL)",5x,"Tem
p."
59: fmt 2,73x,"Rise Rate",9x,"Vxy",11x,"Wind Direction",6x,"Tau"
60: fmt 3,3x,"(min)",3x,"(metres)",3x,"(metres)",3x,"(metres)",3x,"(met
res)"
61: fmt 4,56x,"(degrees C)",4x,"(metres/sec)",4x,"(metres/sec)"
62: fmt 5,101x,"(deg. rel. true north)"
63: wto 6,13;wrt 6.6,r0,r33,r37;wto 6,13;wrt 6.1;wto 6,27,10;wrt 6.2;wr
t 6.3
64: wto 6,27,10;wrt 6.4;wto 6,27,10;wrt 6.5;wto 6,27,10
65: for M=1 to 130;wto 6,95;next M;wto 6,13;wto 6,10
66: fmt 2,1x,f6.1,2x,f9.2,2x,f9.2,2x,f9.2,2x,f9.2
67: fmt 3,32x,f8.2,3x,f8.2
68: fmt 4,1x,f6.1,2x,f9.2,2x,f9.2,2x,f9.2,2x,f9.2,23x,f4.1,12x,f4.1
69: fmt 6,32x,f8.2,3x,f8.2,7x,f6.1
70: fmt 7,1x,f6.1,2x,f9.2,2x,f9.2,2x,f9.2,2x,f9.2,7x,f6.1,11x,f4.1,12x,
f4.1
71: fmt 9,111x,f6.1,7x,f6.1
72: fmt 0,1x,f6.1,24x,f9.2,2x,f9.2,7x,f6.1
73: if N[1]#2^9;jmp 3
74: 0→Z;0→r23;wrt 6,r23,Z,Z+r3),S[1,2];2→F
75: jto "tcalcl"
76: "calc":for F=1 to I
77: if N[I]=2^9;jto "tcalcl"
78: if N[F]#999 and S[F]#999;jto "okay"
79: jto "single"
80: jto "skip"
81: "okay":cos(S[F])sin(N[F])→r3;cos(N[F])cos(S[F])→r4;sin(S[F])→r5
82: sin(S[F])→r6;cos(S[F])sin(C[F])→r8;cos(S[F])cos(C[F])→r7
83: r5r7-r4r3→r9;r3r8-r5r6→r10;r4r6-r3r7→r11
84: √(r9^2+r10^2+r11^2)→r12;r9/r12→r13;r10/r12→r14;r11/r12→r15
85: r13r9+r14r10+r15r11→r16;r37sin(r1)→r17;r37cos(r1)→r18
86: (r16(r6r15-r3r13)+r17(r7r13-r5r14))/r15→r24
87: (r18(r3r15-r5r13)+r17(r4r13-r3r14))/r15→r25;(r18r10+r17r11)/r15→r26

88: r24r3+(r2or24/(r24+r25))r13→X;r24r4+(r26r24/(r24+r25))r14→Y
89: r24r5+(r26r24/(r24+r25))r15→Z
90: r24sin(N[F])cos(S[F])→X[F];r25sin(C[F])cos(S[F])→E[F]
91: r24cos(N[F])cos(S[F])→I[F];r37+r25cos(C[F])cos(S[F])→A[F]
92: r24sin(S[F])→S[F];r37tan(r1)+r25sin(S[F])→P[F]
93: (X[F]-X)*2+X[F]→X[F];(E[F]-X)*2+E[F]→E[F];(N[F]-Y)*2+I[F]→I[F]
94: (I[F]-Y)*2+I[F]→I[F];(S[F]-Z)*2+S[F]→S[F];(A[F]-Z)*2+A[F]→A[F]
95: "skip":if F#1;call "one"(X,r27,Y,r28,Z,r29,I,J,F,r32)
96: X→r27;Y→r28;Z→J[F];F→Q[F];A→R[F];(Z+r45)/2→J;Z→r29→r46
97: r26/(r24+r25)tan(.05)→I;(F-1)/2→r23
98: if flg2;jto "nextF"
99: fmt 1,2x,f6.0,2x,f9.2,2x,f9.2,2x,f9.2,2x,f9.2,2x,f9.2,7x,f6.1
100: if F#1;jto "once"
101: X→r17;Y→r18;Z→r49;if F[F,2]#99;jmp 2
102: wrt 6.2,r23,X,Y,Z,Z+r30;jmp 2
103: wrt 6.1,r23,X,Y,Z,Z+r30,F[F,2]
104: jto "nextF"
105: "once":if F[F,1]#99;jmp 2
106: wrt 6.3,J,J+r30);jmp 2
```

```
107: wrt 6.6,N,N+r30,E[F,1]
108: if E[F,2]#99;jmp 2
109: wrt 6.4,r23,X,Y,Z,Z+r30,H,S;jmp 2
110: wrt 6.7,r23,X,Y,Z,Z+r30,E[F,2],H,S
111: wtb 6,27,10;wrt 6.5,F,1
112: "nextF":if F=1;X→r47;Y→r48;Z→r49
113: next F
114: fmt 7,1x,f5.1,24x,f9.2,2x,f9.2,7x,f5.1
115: if flg8=0;jmp 8
116: "tcalcl":
117: fmt 7,1x,f6.1,24x,f9.2,2x,f9.2,7x,f5.1
118: fmt 6,31x,f9.2,2x,f9.2,7x,f5.1
119: for H=F to r50;(H-1)/2→r23
120: wrt 6.6,Z+40.5,Z+40.5+r30,E[H,1]
121: wrt 6.7,r23,Z+81,Z+81+r30,E[H,2];Z+81→Z
122: next H
123: if flg2;gto "gone"
124: "dataok":ent "Data ok?",Z$;if Z$=U$;gto "five"
125: cfg 0;gsb "fudge"
126: gto "six"
127: "five":wtb 6,12;gto "gone"
128: "single":9999999→r26;if F=2;2.7→H;jmp 2
129: R[F-1]→H
130: Z+30H→Z;if C[F]#999;jmp 2
131: Zsin(A[F])/tan(B[F])→X;Zcos(A[F])/tan(B[F])→Y;jmp 2
132: Zsin(C[F])/tan(D[F])→X;r37+Zcos(C[F])/tan(D[F])→Y
133: X-.005X→K[F];X+.005X→L[F];Y-.005Y→M[F]
134: Y+.005Y→N[F];Z-.005Z→O[F];Z+.005Z→P[F];ret
135: "fudge":ent "Time of reading? (-1 to quit)",r31;if r31=-1;ret
136: ent "Theodolites or Temp.? (1 or 2)",r32;if r32=2;gto +6
137: ent "Theodolite 1 or 2?",r32;if r32=2;gto +4
138: ent "Azimuth 1?",A[r31*2+1],"Elevation 1?",B[r31*2+1]
139: if A[r31*2+1]=2^9;r31*2→r35
140: gto "fudge"
141: ent "Azimuth 2?",C[r31*2+1],"Elevation 2?",D[r31*2+1];gto "fudge"
142: ent "Mid-Point Temp.?",E[r31*2+1,1],"Obs. Point Temp.?",E[r31*2+1,
2]
143: gto "fudge"
144: "one":p1-p2→p2;p3-p4→p4;p5-p6→p6;p2/30→p14;p4/30→p15;p6/30→p7
145: "wnd":√(p2^2+p4^2)/30→p3;atn(p2/p4)→p16;p1→p2;p3→p4;p5→p6
146: gto "wind";if p14>0 and p15>0 or p14<0 and p15>0);gto "wind1"
147: "wind1":p10+p16+180→p9;gto "three"
148: "wind":p10+p16→p9
149: "three":if p9>360;p9-360→p9
150: if p9<0;p9+360→p9
151: ret
152: "gone":46→r22
153: if A[1]=2^9;sfg 7;gto "smoth"
154: for I=1 to r35
155: max(K[I],L[I])→r;min(K[I],L[I])→L[I];r→K[I]
156: max(M[I],N[I])→r;min(M[I],N[I])→N[I];r→M[I]
157: max(O[I],P[I])→r;min(O[I],P[I])→P[I];r→O[I]
158: next I
159: for I=1 to 3
160: r22+I→r33;rr33→C[1];1→F
161: "back":if F>=r35;gto "out"
162: C[F]→J;F→r36;F+1→F
```

```
153: (K[F]-N)/((F-r35)*30) →U[F]; (G[F]-N)/((F-r35)*30) →V[F]
154: if F+1>r35; N+(U[F]+V[F])*30/2→C[F]; gto "out"
155: (K[F+1]-N)/((F+1-r35)*30) →U[F+1]; (G[F+1]-N)/((F+1-r35)*30) →V[F+1]
156: if V[F]>U[F+1]; G[F]→C[F]; gto "back"
157: F+1→F; min(U[F],U[F-1])→U[F]; max(V[F],V[F-1])→V[F]
158: if F+1<=r35; gto "there"
159: N+15(U[F]+V[F])→C[F-1]; N+30(U[F]+V[F])→C[F]; gto "out"
170: "there": (K[F+1]-N)/((F+1-r35)*30) →U[F+1]
171: (G[F+1]-N)/((F+1-r35)*30) →V[F+1]
172: if V[F+1]<=U[F]; gto "pos2"
173: if U[F]=U[F-1]; K[F-1]→C[F-1]; F-1→F; gto "back"
174: N+U[F]*30→C[F-1]; K[F]→C[F]; gto "back"
175: "pos2": if U[F+1]>=V[F]; gto "pos3"
176: if V[F-1]=V[F]; G[F-1]→C[F-1]; F-1→F; gto "back"
177: N+V[F]*30→C[F-1]; G[F]→C[F]; gto "back"
178: "pos3": F-1→Z
179: "again": F+1→F
180: (K[F]-N)/((F-r35)*30) →U[F]; (G[F]-N)/((F-r35)*30) →V[F]
181: if V[F]<=U[F-1] and U[F]>=V[F-1]; gto "loop"
182: F-2→r20
183: "for": for X=Z to r20
184: N+(U[F-1]+V[F-1])*15*(X-r35) →C[X]; next X
185: X-1→F; gto "back"
186: "loop": min(U[F],U[F-1])→U[F]; max(V[F],V[F-1])→V[F]
187: if F+1>r35; F+1→F; F-1→r20; gto "for"
188: gto "again"
189: "out": if I<2; ara C→A; ara 1→K; ara N→L; jmp 2
190: if I<3; ara C→B; ara O→K; ara P→L
191: next I
192: if Flg 3; gto "sb"
193: "smoth": if Flg 7; 2→K; 0→C[1]; jmp 2
194: if Flg 8; r35+1→K
195: if Flg 7 or Flg 3; for J=K to 31; C[J-1]+81.5→C[J]; next J
196: if OS#"yes"; gto "sb"
197: Fmt 0,50x,"ONTARIO MINISTRY OF THE ENVIRONMENT",/
198: Fmt 1,54x,"Salbury Environmental Study",/,61x,"Smoothed Data",/
199: Fmt 2,3x,"Time",2x,"Height (MSL)",2x,"Temp",2x,"Potential Temp"
200: Fmt 3,5x,"PRESSURE",3x,f5.1,10x,"REL. HUMIDITY",3x,f4.0,"%",2/
201: Fmt 4,3x,"(min)",3x,"(metres)",2x,"(deg C)",4x,"(deg C)"
202: Fmt 5,15x,"(deg C/m)",9x,"m/s)",5x,"(metres/sec)"
203: Fmt 5,36x,"(deg rel. true north)",/
204: Fmt 0,5x,"UP DATA:",c35,1/,5x,"DOWN DATA:",c36,1/
205: Fmt 0,10x,f2.0,"/",f2.0,"/",f4.0,15x,f4.0,2/
206: wtb 6,27,10; wrt 6; wrt 6.1; wrt 6.9,r64,r55,r66,r57; wrt 6.6,F$,55
207: wrt 6.3,Z,R; wrt 6.2; wtb 6,27,10
208: Fmt 3,44x,"P.P.Lapse Rate",2x,"Rise Rate",5x,"Vxy",11x,"Wind Direc
tion"
209: wrt 6.3
210: wrt 6.6; wtb 6,27,10; wrt 6.5; wtb 6,27,10; wrt 6.6; wtb 6,27,10; wtb 6,
27,1)
211: for I=1 to 132; wtb 6,95; next I; wtb 6,13
212: Fmt 0,1x,f5.1,2x,f0.2,3x,f5.1,5x,f7.1,3x,f3.5,5x,f6.1,5x,f5.1,12x,
f5.1
213: Fmt 1,1x,f5.1,2x,f0.2,13x,f5.1,5x,f5.1,5x,f5.1
214: Fmt 2,1x,f5.2,2x,f0.2,3x,f5.1,5x,f7.1,3x,f3.5,5x,f5.1
215: Fmt 3,1x,f0.2,3x,f5.1,5x,f7.1,3x,f3.5
```

```
216: fmt 4,9x,f9.2
217: fmt 5,1x,f5.1,2x,f9.2,3x,f5.1,3x,f7.1
218: fmt 6,1x,f5.1,2x,f9.2
219: if flg 7;gto "bottemp"
220: "asp":A[1]→r27;B[1]→r23;C[1]→r29
221: for I=2 to r35; (I-1)/2→r23
222: cll 'one'(A[I],r27,B[I],r23,C[I],r29,T,S,F,r38)
223: S→K[I];F→L[I];next I
224: if B[1,2]=99 or B[1,1]=99;sfg 1);gto "psmot"
225: "bottemp":273→r51;.03415→r52;.2856→r53;0→P
226: for K=1 to 34;B[K,2]→N[K];B[K,1]→C[K];next K
227: (N[1]+r51)*(1000/P)^r53-r51→B[1,2]
228: for K=2 to 34;(C[K]-C[K-1])/2→r56;if N[K]=99;gto "psmot"
229: cll 'theta'(P,C[K],r51,N[K-1],r56,r52,r53,B[K,1])
230: cll 'theta'(P,N[K],r51,C[K],r56,r52,r53,B[K,2]);next K
231: gto "psmot"
232: "theta":if p2-p4=0;p1*exp(p5*p6/(p4+p3))→p1;jmp 2
233: p1*((p2+p3)/(p4+p3))^(p5*p6/(p4-p2))→p1
234: (p2+p3)*(1000/p1)^p7-p3→p3;ret
235: "psmot":if O$#"yes";gto "store"
236: 1→I;if flg7;r50→r35;wrt 6.5,0,C[I]+r30,N[I],B[I,2];jmp 4
237: if flg10;wrt 6.6,0,C[1]+r30;jmp 3
238: wrt 6.5,0,C[1]+r30,N[I],B[1,2]
239: if flg8;r35→r53;r50→r35
240: for I=2 to r35;cll 'rate'(C[I],C[I-1],B[I,1],B[I,2],B[I-1,2],Z,W,V
,H)
241: (I-1)/2→r23;if flg7;jmp 6
242: if flg10=0;jmp 2
243: if N[I]=99 or flg10);sfg 10;jmp 3
244: wrt 6.3,Z+r30,C[I],B[I,1],W
245: wrt 6,r23,C[I]+r30,N[I],B[I,2],V,H,K[I],L[I];gto "ni"
246: wrt 6.4,Z+r30;wrt 6.1,r23,C[I]+r30,H,K[I],L[I];gto "ni"
247: wrt 6.3,Z+r30,C[I],B[I,1],W
248: wrt 6.2,r23,C[I]+r30,N[I],B[I,2],W,H
249: "ni":next I
250: -99→L[r35+1]
251: gto "store"
252: "rate":(p1-p2)/2+p2→p5;(p3-p5)/(p6-p2)→p7
253: (p4-p3)/(p1-p6)→p8;(p1-p2)/30→p9;ret
254: if flg 0=1;gto "jump"
255: "store":dsp "DATA DISC";stp
256: "oj":ara C→D
257: r64→I;r65→S;r66→T;r67→N;fxd 2
258: str(I)→I$[1];I$[2]→I$[1]
259: str(S)→I$[3];I$[4]→I$[3]
260: str(T-1970)→I$[5];I$[6]→I$[5]
261: char(int(N/100)+61)→I$[6]
262: I$[1,6]→H$
263: dsp H$,"correct date & time?";stp
264: "asgn":asgn H$,1,0,K
265: if X=1;gto "open"
266: sort 1,C[*],B[*],K[*],L[*],F$,G$,I,S,T,N,2,R,"end";jmp 2
267: "open":open H$,12;gto "asgn"
268: fxd 0;prt I,"/",S,"/",T,"  ",N,"data stored as",I$
269: "se":if flg5;gto "sf"
270: if O$#"yes";stp ;dsp "press run"
271: beep;dsp "set plotter";stp ;if r23>7.5 and r23<13;wto 6,12;jmp 2
272: fmt 0,4/;wrt 6
```

```
273: scl -4,41.5,-.2,2.7;plt 0,0,1;plt 0,.1,2
274: for I=.1 to 2.5 by .1;plt 0,I;plt -.2,I;plt .2,I;plt 0,I;next I;pl
t 0,0,1
275: plt 1,0,2
276: for I=1 to 40;plt I,0
277: if I=11 or I=25;plt I,.1;plt I,0;jmp 2
278: plt I,.013;plt I,-.013;plt I,0
279: next I
280: csiz 1.75;fxd 0;plt 10,2.5,1;lbl "ses - copper cliff"
281: csiz 1.25;plt 10,2.44,1;lbl r64,"/",r65,"/",r66
282: plt 10,2.39,1;lbl r67;fxd 1
283: plt 0,.5,1;cplt -2.3,-.3;lbl ".5"
284: for I=1 to 2.5 by .2;plt 0,I,1;cplt -4.3,-.3;lbl I;next I
285: csiz 1.25;plt 0,.681,1;plt -.55,.681,2;cplt -2.5,-.4;lbl "sh"
286: plt 0,r30/1000,1;plt -.55,r30/1000,2;cplt -2.5,-.4;lbl "gl"
287: csiz 1;fxd 0
288: for I=2 to 20 by 2;plt I/2,0,1;cplt -1.5,-1.3;lbl I;next I
289: B[1,2]→r2;B[2]→r3→r4;r35→r21;0→F
290: for I=2 to r35;min(r2,C[I,1])→r2;min(r3,B[I,2])→r3;next I
291: for I=2 to r35
292: min(D[I],r3)→r3;max(D[I],r4)→r4
293: if (C[I]+r30)/1000>=2.51;I-1→r21;jmp 2
294: next I
295: r2→r43;if r3<=25 or r4>=335;gto "180-180"
296: for I=12 to 24 by 2;plt I,0,1;cplt -2,-1.3;lbl F;F+60→F;next I
297: gto +4
298: "180-180":180→F
299: for I=12 to 24 by 2;if F=420;60→F
300: plt I,0,1;cplt -2,-1.3;lbl F;F+60→F;next I
301: for I=26 to 40 by 2;plt I,0,1;cplt -2,-1.3;lbl r43;r43+4→r43;next
I
302: plt 3,0,1;cplt 0,-3;lbl "wind speed (m/s)"
303: plt 13,0,1;cplt 0,-3;lbl "wind direction (degrees)"
304: plt 29,0,1;cplt 0,-3;lbl "Potential Temp. (deg. C)"
305: csiz 1.5,1,1,90;plt 0,.3,1;cplt -.5,2.3;lbl "height (km-msl)"
306: csiz .75,1,1,0
307: for I=2 to r21;if K[I]=0 and L[I]=0;gto "L[]"
308: plt K[I]/2,(C[I]+r30)/1000;iplt 0,0
309: next I
310: "L[]":plt 11,0,1;if r3<=25 or r4>=335;gto +4
311: for I=2 to r21;if L[I]=0 and K[I]=0;gto "F[]"
312: plt L[I]/30+12,(C[I]+r30)/1000
313: iplt 0,0;next I;gto +7
314: for I=2 to r21;if L[I]=0 and K[I]=0;gto "F[]"
315: if L[I]>=180;jmp 3
316: plt L[I]/30+18,(C[I]+r30)/1000
317: iplt 0,0;gto "nextwind"
318: plt L[I]/30+6,(C[I]+r30)/1000);iplt 0,0
319: "nextwind":next I
320: "E[]":plt 25,0,1;if flg8=0;r35→r50
321: for I=1 to r50;if C[I]+r30>2500;gto "ott"
322: if E[I,1]=99 or I=1;jmp 3
323: plt (E[I,1]-r2)/2+25,((C[I]+C[I-1])/2+r30)/1000
324: iplt 0,0;C[I]→r34
325: if E[I,2]=99;jmp 3
326: plt (E[I,2]-r2)/2+25,(C[I]+r30)/1000
327: iplt 0,0;C[I]→r34
328: next I
329: "ott":if flg6;gto "end"
```

```
330: "end":
331: "ott":ent "CHOOSE MIXING HEIGHT",M;if M=-1;gto "StArt"
332: ent "Wind Data?",V$;if V$=JS;sfg 5
333: if flg 5=0;gto "prt"
334: for J=1 to r35;if C[J]+r30>1;J-1→r53;gto "eval"
335: next J
336: "eval":0→r59;0→r50
337: for J=2 to r53;K[J]cos(L[J])*(C[J]-C[J-1])+r59→r59
338: K[J]sin(L[J])*(C[J]-C[J-1])+r60→r60;next J
339: K[J]sin(L[J])*(M-C[J-1]-r30)+r60→r60
340: K[J]cos(L[J])*(M-C[J-1]-r30)+r59→r59
341: r59/(M-r30)→r59;r60/(M-r30)→r60;(r59^2+r60^2)^.5→V
342: abs(atn(r60/r59))→O;prt O;if r60>0 and r59>0;90-O→O;jmp 4
343: if r59>0 and r60<0;O+270→O;jmp 3
344: if r59<0 and r60<0;270-O→O;jmp 2
345: if r59<0 and r60>0;O+90→O
346: "prt":fmt 0,5/,25x,"*****************************************
***"
347: fmt 1,23x,"MIXING HEIGHT",3x,f9.1,2x,"metres",2/
348: fmt 2,23x,"MIXED LAYER WIND VECTOR",/
349: fmt 3,35x,"Vxy",3x,f4.1,2x,"m/s",3x,"DIRECTION",f9.1,2x,"deg.rel.t
rth"
350: wrt 6;wrt 6.1,M;if flg 5;wrt 6.2;wrt 6.3,V,O;wrt 6
351: vto 6,12,12
352: sfg ;lbl "press RUN";sto
353: end
*27412
```

Appendix 3

Hourly Average Solar Radiation Data

MINISTRY OF THE ENVIRONMENT

SURFACE ATMOSPHERIC STUDY

SOLAR FLUX

LANGLEYS / SQ. F.

Month: JANUARY 1979

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7- 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8- 9	8	0	33	16	33	0	0	8	*	*	*	16	0	16	49	57	0	74	33	0	0	8	33	0	8	25	16	8	16	33	41
9-10	66	74	148	131	180	57	123	164	*	*	*	57	49	74	213	164	41	197	82	33	66	107	82	0	33	98	73	61	82	180	143
10-11	107	213	237	164	303	115	172	311	*	*	*	130	107	148	344	262	98	279	164	107	148	130	143	115	74	213	143	135	139	303	246
11-12	156	336	361	262	401	197	303	377	*	*	*	213	198	279	413	377	156	361	180	148	197	246	213	123	74	246	205	197	279	410	336
12-13	180	361	410	311	475	279	311	418	*	*	*	213	213	335	475	459	213	434	180	139	221	303	213	217	127	254	246	205	283	492	369
13-14	156	369	295	303	246	323	213	426	*	*	*	205	180	335	442	434	205	508	138	115	238	410	205	115	82	279	238	176	377	393	442
14-15	98	262	197	262	164	205	123	361	*	*	*	197	139	311	361	344	180	459	143	107	180	328	164	123	57	229	197	160	262	311	453
15-16	16	123	115	148	82	90	57	221	*	*	*	98	66	130	138	197	115	270	123	32	115	213	90	45	41	197	115	115	164	213	33
16-17	0	8	8	25	0	8	8	49	*	*	*	0	0	49	33	49	33	98	49	8	49	65	33	16	29	33	33	51	51	74	66
17-18	0	0	0	0	0	0	0	0	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8	12	8
18-19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX

WATTS / SQ. M.

Month: FEBRUARY 1979

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7- 8	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	16	8	25	8	0	*	0	0	8	25	25	0
8- 9	33	98	66	25	25	16	25	49	41	74	98	*	*	33	49	66	139	172	123	57	33	*	33	107	143	180	164	57
9-10	131	235	229	90	107	74	123	180	98	180	213	*	*	115	107	197	254	238	323	172	57	*	66	197	369	361	369	188
10-11	238	459	336	229	188	90	254	323	188	303	279	*	*	197	156	393	323	328	418	270	74	*	49	410	492	500	524	336
11-12	303	565	500	279	238	123	311	451	295	369	254	*	*	323	221	492	369	426	503	369	131	*	66	573	598	410	505	535
12-13	393	500	516	352	270	164	303	524	352	413	320	*	*	270	303	565	393	492	523	535	139	*	49	614	614	229	631	631
13-14	401	426	434	287	279	156	303	533	344	467	336	*	*	336	295	555	410	483	590	344	115	*	57	598	516	590	614	533
14-15	336	336	303	205	254	123	246	426	328	500	323	492	*	323	287	500	418	467	426	287	74	410	74	516	401	483	553	344
15-16	311	246	172	156	197	115	148	303	303	402	205	369	361	164	221	369	418	459	410	205	57	254	41	393	311	401	401	229
16-17	172	139	82	74	115	57	57	148	148	262	74	188	197	74	90	197	262	254	229	131	57	180	25	197	172	287	233	172
17-18	33	8	8	16	16	8	8	25	8	33	16	33	41	16	16	41	41	46	57	25	33	49	16	66	41	90	57	66
18-19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX

WATTS / SQ. M.

Month: MARCH 1979

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 7	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	16	0	0	0	0	0	0	0	0	57	0	0	0	0
7- 8	0	0	0	0	0	0	25	0	0	0	16	0	*	33	82	65	107	197	131	197	49	57	123	0	33	65	254	139	74	0	0
8- 9	66	66	16	82	33	25	115	98	131	16	90	0	*	172	229	154	229	221	295	344	246	115	156	0	57	139	467	279	164	41	0
9-10	164	139	33	41	57	123	229	139	352	107	148	123	*	246	279	262	393	295	459	483	467	287	139	33	221	303	606	401	459	33	57
10-11	238	229	107	57	66	246	295	221	533	205	262	377	*	328	492	361	655	442	606	647	593	549	303	57	328	459	729	631	164	74	164
11-12	459	352	172	90	98	303	410	680	459	238	311	655	*	442	582	573	680	705	680	721	696	614	434	98	311	770	803	664	238	57	221
12-13	590	516	172	90	123	393	524	672	492	279	377	860	*	590	606	680	705	729	672	705	680	729	467	74	352	778	811	778	696	41	331
13-14	475	590	254	66	131	410	434	639	328	344	393	803	*	541	696	695	680	705	590	713	508	606	500	98	262	754	786	762	803	66	623
14-15	311	533	279	57	82	303	361	573	238	172	377	721	*	508	696	614	606	393	524	614	475	606	303	90	279	598	606	606	606	82	66
15-16	205	377	221	41	66	164	246	467	156	123	279	573	*	434	573	492	475	238	377	475	467	451	156	74	238	434	557	311	475	41	524
16-17	115	205	131	33	33	98	131	164	98	90	180	270	*	385	442	344	328	180	361	328	221	311	107	49	156	270	385	90	279	0	361
17-18	33	49	25	41	0	16	41	66	41	74	49	49	*	164	279	138	180	41	13	115	82	107	33	16	74	115	172	33	107	0	197
18-19	0	0	0	0	0	0	0	0	0	0	0	0	*	0	115	33	57	0	0	0	0	0	0	0	8	0	0	0	0	0	25
19-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

FIDELITY OF THE ENVIRONMENT

FIDELITY ENVIRONMENTAL STUDY

SOLAR FLUX

WATTS / SQ. M.

Month: APRIL 1979

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	33	8	16	8	*	0	0	0	*	*
6- 7	66	0	66	82	57	0	90	90	49	115	155	16	57	8	25	131	115	131	131	66	66	33	139	131	*	8	49	33	*	*
7- 8	238	16	246	254	156	57	279	279	164	287	303	57	98	25	74	107	270	344	335	82	70	115	352	238	*	16	66	82	*	*
8- 9	442	25	456	344	320	131	433	393	433	433	467	66	320	66	41	139	475	533	524	180	119	434	541	393	*	41	164	164	*	*
9-10	623	74	623	401	541	344	655	459	573	555	647	197	188	98	115	213	721	688	672	229	131	680	680	500	*	53	238	229	*	*
10-11	778	90	762	410	459	459	795	573	736	795	770	156	377	131	279	328	811	786	786	303	98	803	795	762	*	41	221	262	*	*
11-12	827	98	827	451	475	442	868	590	852	850	778	270	33	205	492	614	868	868	852	533	66	860	835	778	*	33	254	238	*	*
12-13	844	74	836	361	533	492	893	541	860	877	819	197	16	131	352	605	893	835	852	705	70	877	909	*	*	33	157	115	*	*
13-14	803	74	795	279	786	492	852	549	778	852	762	131	49	93	156	868	852	819	827	819	66	836	836	*	205	49	188	197	*	*
14-15	672	66	705	197	573	524	754	483	688	754	969	139	33	123	90	770	762	754	721	696	147	737	729	*	188	49	147	8	*	*
15-16	524	82	557	139	442	492	598	377	606	606	500	90	16	98	82	614	606	598	582	492	252	582	582	*	123	33	98	2	*	*
16-17	295	33	361	90	262	279	434	229	426	418	237	74	8	98	74	451	434	426	410	279	86	426	401	*	41	16	25	0	*	*
17-18	82	8	164	0	107	74	205	123	164	221	139	25	0	74	57	238	254	254	246	180	25	138	172	*	33	8	0	0	*	*
18-19	0	0	25	0	8	25	25	49	49	49	0	0	8	8	41	82	82	49	*	49	16	33	57	*	8	4	0	0	*	*
19-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

FLORIDA SOLAR ENERGY CENTER

SOLAR ENVIRONMENTAL STUDY

SOLAR FLUX

LANGLEY / SQ. M.

Month: MAY 1977

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	2	*	*	*	*	0	0	2	0	2	0	0	0	2	2	0	0	2	2	0	0
5- 6	0	0	2	2	2	3	2	2	3	7	2	*	*	*	*	2	2	3	2	3	3	3	3	3	3	3	2	3	3	2	2
6- 7	24	29	38	47	49	55	22	12	47	122	141	*	*	*	*	2	2	31	38	21	62	56	76	57	87	73	33	21	69	69	91
7- 8	140	213	204	203	165	245	88	71	231	300	332	*	*	*	*	62	85	147	172	95	194	187	235	70	73	219	244	82	239	245	262
8- 9	254	320	373	392	325	438	209	242	406	436	545	304	460	*	*	140	350	126	351	223	366	335	413	351	187	391	416	94	422	389	442
9-10	386	507	576	579	503	636	435	292	641	557	592	275	624	*	657	294	481	215	520	564	558	551	593	560	339	547	599	295	602	491	617
10-11	517	586	730	727	458	774	735	354	800	736	798	334	580	779	799	408	400	334	671	585	695	699	737	585	345	690	677	270	754	633	749
11-12	511	849	851	845	641	801	878	497	915	896	856	408	457	989	876	238	761	137	780	686	804	815	840	821	893	858	761	533	867	714	352
12-13	842	918	834	855	297	175	840	523	980	936	864	908	451	945	915	293	829	332	798	946	858	870	914	915	914	933	856	184	937	896	905
13-14	864	1003	856	839	207	379	827	425	717	933	858	886	561	959	909	685	833	433	883	931	864	879	911	920	880	950	895	219	958	921	802
14-15	821	946	804	834	165	569	871	334	776	865	812	812	848	890	849	934	795	394	673	776	826	830	876	873	918	915	864	225	933	931	837
15-16	690	903	690	795	88	636	811	219	856	767	750	466	632	792	742	740	492	270	185	633	739	683	793	790	824	757	803	549	856	840	688
16-17	497	746	627	555	59	577	666	441	524	520	536	495	541	569	455	508	106	411	201	570	605	591	654	668	715	613	624	547	742	654	663
17-18	276	549	535	410	32	397	482	201	394	416	430	122	430	332	370	480	129	454	72	419	630	414	473	516	519	555	510	583	588	608	303
18-19	32	278	338	235	44	259	248	137	125	210	217	215	294	229	225	303	71	194	334	238	218	256	275	339	335	381	212	419	375	398	140
19-20	13	125	122	110	16	107	59	32	35	66	41	125	147	110	44	134	35	134	123	62	94	75	121	168	147	174	22	169	147	210	59
20-21	3	7	4	4	6	3	2	3	2	2	2	28	16	3	2	21	5	12	10	9	10	12	9	34	32	32	21	54	57	54	2
21-22	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	2	2	2	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

[illegible] OF THE ENVIRONMENT

SOLIDIFY EVITION DATA STUDY

SOLAR FLUX

WATTS / SQ. M.

Month: MAY 197[illegible]

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	
6- 7	*	*	2	33	*	*	4	8	4	4	33	16	49	8	15	65	41	49	4	16	8	65	25	25	16	1	16	16	25	41	74
7- 8	*	*	8	139	*	*	82	53	122	25	82	25	213	25	163	228	221	130	172	25	16	229	90	205	139	33	86	65	49	131	221
8- 9	*	*	33	344	*	*	229	213	295	49	115	98	335	147	391	399	377	344	344	123	25	401	262	352	369	90	186	98	147	328	410
9-10	*	*	49	459	*	*	426	418	459	32	164	130	573	442	587	677	524	246	549	377	66	598	319	623	614	66	246	123	157	590	592
10-11	*	*	49	671	*	*	623	557	598	131	323	234	737	580	717	766	705	606	636	811	156	778	492	762	762	147	328	213	311	705	721
11-12	*	*	82	778	*	*	754	737	538	130	508	451	860	590	750	856	850	770	813	877	205	858	566	836	729	131	578	65[illegible]	246	806	830
12-13	*	*	74	778	*	*	819	803	557	262	541	893	913	598	815	937	925	557	901	913	344	942	590	958	729	172	639	713	287	942	909
13-14	*	*	74	539	*	*	858	770	623	205	813	557	950	721	652	962	950	721	913	934	500	957	410	983	715	164	506	713	852	819	852
14-15	*	*	82	328	*	*	844	721	705	252	762	252	926	745	571	921	918	736	835	901	442	737	246	958	5[illegible]	115	705	492	893	172	893
15-16	*	754	74	130	*	*	*	360	557	335	107	229	827	532	403	832	836	762	745	835	319	565	237	868	532	90	705	147	655	573	795
16-17	*	352	66	270	*	*	*	295	492	503	279	303	713	459	122	701	713	547	336	541	287	508	155	715	647	49	541	205	606	614	686
17-18	*	205	66	270	*	*	*	279	295	323	336	123	557	369	114	533	524	500	279	229	295	279	139	500	352	82	492	213	328	205	516
18-19	*	90	33	164	*	*	*	213	93	180	147	98	360	295	130	342	295	123	246	131	221	130	32	401	131	98	410	74	328	180	360
19-20	*	49	16	66	*	*	*	106	98	115	49	33	147	156	147	153	115	4	90	106	90	66	57	221	57	25	139	33	92	115	123
20-21	*	2	0	16	*	*	*	16	33	49	8	6	41	15	24	33	25	0	4	16	25	8	6	41	0	1	41	12	49	41	16
21-22	*	0	0	0	*	*	*	0	0	0	0	0	0	0	4	0	0	0	0	0	2	0	0	2	0	0	2	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX

WATTS / SQ. M.

Month: JUNE 1977

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0
4- 5	0	0	0	0	0	0	2	0	2	0	*	*	*	*	36	0	2	0	0	3	0	0	0	0	*	*	*	*	3	0
5- 6	2	0	3	0	0	0	2	9	2	2	*	*	*	*	91	3	3	9	2	4	7	9	7	2	*	*	*	9	9	16
6- 7	2	3	113	0	47	18	47	129	116	69	*	*	*	*	160	13	37	75	25	49	115	135	96	2	*	*	*	97	51	11
7- 8	26	29	304	40	179	59	210	310	241	231	*	*	*	*	295	100	43	105	157	83	300	234	234	2	*	*	*	281	100	279
8- 9	78	87	316	84	367	154	375	331	442	407	*	*	426	*	457	290	84	253	122	93	491	472	450	97	*	456	393	444	411	492
9-10	107	335	470	113	535	420	855	611	635	533	*	*	591	*	508	419	96	291	272	187	553	635	577	185	*	554	475	548	404	557
10-11	125	477	653	128	752	661	755	780	801	742	*	*	730	*	774	546	159	295	430	259	595	640	745	179	*	735	477	724	353	717
11-12	209	840	782	190	808	751	874	926	830	881	*	*	834	783	857	716	251	344	410	212	707	765	836	182	*	789	293	855	466	854
12-13	319	999	952	144	834	875	937	1053	949	926	*	*	839	905	939	559	382	113	350	339	800	817	733	391	735	843	237	793	401	555
13-14	310	1005	992	320	995	730	993	939	812	965	*	*	854	685	933	673	209	30	410	400	818	704	776	836	403	357	494	905	225	350
14-15	192	1006	923	187	726	652	987	901	803	912	*	*	911	533	850	645	356	81	345	569	792	372	552	653	313	926	294	784	129	284
15-16	198	862	836	112	653	646	836	893	595	842	*	*	808	486	720	344	331	170	465	321	768	495	733	392	347	860	447	450	151	349
16-17	360	760	717	74	256	773	716	339	535	729	*	*	370	270	569	130	442	225	393	515	605	515	467	311	223	616	311	283	184	229
17-18	254	576	566	34	140	605	627	411	401	550	*	*	375	140	567	51	403	344	309	451	342	629	203	225	229	495	190	156	311	98
18-19	250	369	382	38	51	463	379	234	140	435	*	*	245	123	367	65	317	401	265	314	219	523	119	212	220	305	125	43	301	82
19-20	32	215	213	58	19	336	242	159	215	235	*	*	163	208	97	46	165	175	179	137	134	238	93	151	162	128	91	16	151	16
20-21	3	56	65	38	38	150	97	58	53	82	*	*	56	32	25	15	51	53	44	93	43	79	23	47	44	22	19	3	21	3
21-22	0	0	0	0	3	30	4	0	2	3	*	*	0	2	0	3	3	3	2	4	3	3	3	3	2	2	2	2	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX

WATTS / SQ. M.

Month: JUNE 1978

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1- 4	0	0	0	0	49	8	0	8	0	0	0	0	4	0	0	0	1	4	*	0	0	0	3	0	0	0	0	0	5	0
4- 5	0	0	0	0	49	8	0	8	0	0	0	4	8	0	0	0	4	4	*	0	0	0	0	0	0	0	0	0	5	0
5- 6	0	0	16	8	49	8	0	8	8	4	0	4	8	0	7	0	0	3	*	*	0	20	7	13	0	1	0	12	4	3
6- 7	0	62	35	32	82	33	66	33	110	53	53	41	64	*	92	25	29	12	*	*	51	103	48	38	29	14	0	94	92	15
7- 8	*	197	246	208	174	200	161	131	172	193	119	21	246	*	235	41	35	23	*	*	66	323	102	198	185	34	143	257	253	28
8- 9	*	231	448	364	467	423	225	258	120	290	250	45	467	*	403	57	191	131	*	*	108	431	217	348	229	94	226	431	453	45
9-10	*	312	557	471	661	594	549	313	125	611	383	139	636	627	633	115	349	41	*	*	161	623	564	472	316	83	201	598	317	59
10-11	*	295	252	648	762	730	631	517	153	726	637	132	791	787	746	103	472	123	*	*	97	776	782	672	283	188	139	677	733	754
11-12	631	287	439	636	846	833	516	535	271	849	816	45	918	891	766	111	647	344	*	863	87	589	889	817	236	127	147	663	776	371
12-13	483	307	795	500	918	903	640	664	600	393	877	45	935	922	953	198	233	900	*	917	46	523	966	920	647	62	529	670	*	935
13-14	180	558	591	600	800	938	702	*	820	841	865	781	010	886	977	459	513	977	*	930	666	399	1010	935	803	83	588	667	*	941
14-15	233	446	508	126	746	894	636	*	817	698	873	140	979	956	564	669	206	713	*	804	303	517	892	910	673	175	558	339	832	901
15-16	420	361	735	108	815	810	572	*	787	759	796	239	889	897	764	689	712	645	*	805	615	230	876	810	804	217	808	567	815	790
16-17	648	444	569	107	664	647	180	694	656	296	685	283	689	604	649	541	573	643	*	594	579	123	720	682	475	224	608	511	681	626
17-18	418	259	213	771	464	516	116	418	569	137	531	230	469	522	603	115	411	435	*	551	379	56	541	533	462	317	472	522	443	390
18-19	94	231	233	61	353	349	82	305	435	78	316	98	317	435	332	33	247	221	*	369	397	38	346	371	299	316	337	340	277	303
19-20	95	164	167	25	153	179	33	172	246	45	94	65	159	225	200	8	132	156	*	185	198	38	236	208	122	185	234	203	192	175
20-21	*	328	66	8	57	49	0	74	32	12	29	21	77	72	59	0	45	41	*	61	53	23	74	62	34	50	40	53	66	25
21-22	0	8	8	0	0	8	0	0	0	4	0	0	5	4	7	0	4	8	*	3	1	3	7	5	0	0	4	0	4	3
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX

WATTS / SQ. M.

Month: JULY 1979

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	2	0	0	2	0	0	0	0	0	0	0	0	2	0	*	0	0	7	3	0	0	0	0	0	2	0	0	0	0	0
6- 7	82	33	74	66	25	33	33	16	16	33	25	49	82	49	49	49	16	33	82	90	82	8	8	98	82	74	74	49	66	0
7- 8	229	254	238	180	147	254	82	49	74	8	131	328	254	229	139	90	25	245	245	270	180	25	49	270	238	197	98	229	205	8
8- 9	393	377	418	336	295	442	287	66	107	98	360	410	451	410	254	16	66	459	426	451	197	98	82	459	418	262	319	401	377	66
9-10	573	590	590	393	524	573	467	82	115	377	655	606	614	516	197	82	131	639	606	614	323	180	156	639	590	475	492	573	557	123
10-11	754	737	737	369	631	762	631	434	139	147	795	655	770	737	459	565	393	795	754	737	549	237	197	746	754	713	737	737	582	197
11-12	803	844	852	655	623	885	737	475	131	336	909	852	885	737	557	860	213	773	868	844	786	451	295	901	860	745	729	516	598	90
12-13	819	926	926	901	811	901	852	573	147	819	852	835	950	819	630	860	115	778	942	909	737	508	295	967	934	557	770	410	860	90
13-14	819	934	967	934	811	967	811	827	147	827	803	926	975	778	794	913	180	975	967	934	737	557	197	909	975	713	344	311	639	66
14-15	565	934	745	778	811	926	754	803	352	754	811	967	950	819	630	885	49	958	934	901	705	647	262	958	868	323	302	590	623	107
15-16	213	786	745	598	721	786	672	82	279	98	631	606	852	721	483	819	66	877	835	819	631	508	147	877	672	164	721	426	778	98
16-17	49	705	680	606	680	557	614	475	139	66	598	614	729	664	254	672	49	745	721	655	573	164	180	721	762	131	319	655	524	66
17-18	49	549	541	500	557	295	459	393	57	90	377	573	492	451	156	524	74	573	573	344	369	41	147	590	598	82	319	410	672	82
18-19	82	377	377	221	393	131	278	295	33	41	319	369	377	238	295	328	66	377	393	229	323	41	180	401	418	16	262	418	344	66
19-20	49	197	188	131	205	82	147	172	16	33	164	139	205	131	131	180	49	197	205	82	123	25	197	205	238	4	82	205	180	25
20-21	8	49	49	16	57	33	49	57	2	8	41	49	98	33	33	49	16	74	66	41	33	8	66	82	57	4	57	82	66	8
21-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	8	12	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	0	0	0	0	*	0	*

* = unavailable data

SOLAR FLUX

Month: JULY 1977

DAY

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0-1	0	0	0	0	0	0	1	1	2	3	3	0	0	3		0	1	1	2	1	2	3	1	0	1	2	3	0	1	2	2
1-2	0	0	0	0	0	0	0	1	2	3	*	3	0	*	1	2	2	3	1	1	2	2	3	0	1	2	2	0	0	2	1
2-3	7	2	4	2	12	2	3	2	3	2	*	2	1	*	2	3	3	2	1	3	3	3	3	0	7	3	0	2	2	3	2
3-4	74	29	100	29	135	6	19	25	91	91	*	69	69	*	19	71	81	75	19	71	53	33	53	15	100	34	41	43	18	22	30
4-5	254	57	273	75	257	59	45	90	239	247	173	201	237	*	31	91	107	237	73	173	238	255	135	29	231	241	162	217	37	104	100
5-6	255	104	428	100	359	54	76	151	511	447	401	190	235	*	72	401	152	425	154	136	334	432	454	4.	457	476	372	179	51	157	120
6-7	259	476	502	630	601	37	103	231	642	613	583	109	375	551	325	536	173	629	433	433	613	603	403	56	632	516	545	253	207	375	215
7-8	198	613	541	737	753	91	251	306	552	771	607	47	541	557	472	760	375	632	713	703	751	774	705	103	802	345	593	295	525	761	323
8-9	118	532	569	732	874	87	225	604	502	899	635	50	615	519	567	337	592	624	303	751	865	735	543	163	801	915	802	539	391	774	144
9-10	239	645	570	321	564	101	319	435	533	956	355	187	632	435	653	501	725	804	352	595	867	754	754	233	653	301	870	353	234	373	244
10-11	244	309	419	395	540	175	287	541	332	956	905	201	520	451	517	398	309	811	393	753	936	752	813	522	502	752	543	356	347	921	223
11-12	198	933	324	876	551	251	272	896	552	923	854	121	411	404	544	371	930	813	351	732	925	693	770	543	535	558	858	617	469	870	223
12-13	239	874	143	802	466	329	351	736	745	854	773	84	527	335	573	304	329	632	770	707	793	564	431	245	773	542	771	372	370	789	112
13-14	213	757	107	535	335	470	413	703	524	732	573	79	656	317	505	595	735	328	667	543	639	511	507	63	708	535	472	184	122	679	112
14-15	259	594	64	518	142	468	242	535	101	547	557	334	653	532	453	544	517	233	535	430	549	535	107	38	539	314	442	61	250	451	303
15-16	94	425	32	314	102	176	154	307	331	359	391	341	453	373	356	379	435	156	345	223	305	254	336	12	281	235	352	41	47	332	274
16-17	180	242	13	125	62	101	47	226	172	225	201	54	256	226	94	249	257	50	176	76	179	84	150	10	172	170	150	13	40	154	114
17-18	25	79	2	11	24	32	15	74	72	76	33	10	72	35	32	61	93	13	44	24	52	45	24	5	33	32	22	2	4	15	7
18-19	2	6	0	2	0	2	2	2	3	3	2	2	3	0	0	2	7	0	0	0	0	0	0	2	2	2	0	0	0	0	0
19-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

[illegible]

[illegible]

SOLAR FLUX

[illegible]

Month: JULY 197[illegible]

DAY

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0- 1	0	0	0	0	7	0	0	0	0	0	0	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1- 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2- 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 7	97	52	41	0	112	16	25	51	33	16	16	0	0	21	10	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	0
7- 8	246	254	87	205	246	45	52	57	151	82	93	167	45	52	55	221	202	213	71	41	71	33	52	157	154	41	172	197	8	203	310
8- 9	430	402	172	413	390	74	123	41	223	191	172	400	21	230	273	332	335	359	131	93	340	82	115	365	325	93	305	372	0	362	530
9-10	565	599	379	531	539	92	213	139	407	262	492	554	29	317	197	251	551	533	271	399	344	252	297	540	520	243	515	551	25	554	525
10-11	736	738	572	740	740	243	335	85	502	523	510	712	37	507	492	349	710	513	230	640	523	295	549	535	677	344	655	704	74	707	502
11-12	690	628	907	845	656	255	472	130	454	413	705	827	53	756	230	342	535	144	522	740	549	348	530	512	751	335	741	327	102	617	637
12-13	705	902	1123	913	910	492	476	443	333	435	712	917	70	825	353	553	907	194	130	722	824	492	338	394	836	540	738	552	250	904	392
13-14	771	959	941	943	833	587	335	230	513	525	733	953	91	913	425	325	940	174	115	804	446	139	812	918	886	787	656	922	153	922	669
14-15	831	799	897	771	657	314	692	410	374	620	913	925	103	638	351	374	907	151	279	836	879	235	833	861	820	592	372	857	554	907	633
15-16	731	859	851	754	705	254	541	512	358	393	694	345	463	702	561	315	322	41	303	589	663	159	758	776	303	504	255	792	318	845	730
16-17	446	672	768	694	656	279	571	679	492	361	807	725	512	659	735	723	707	41	245	574	410	139	694	677	295	325	599	579	297	701	432
17-18	428	372	532	474	251	331	517	540	279	397	540	564	435	539	255	575	519	92	205	535	323	82	532	533	132	164	508	399	259	540	135
18-19	235	303	332	336	87	343	325	305	148	464	515	387	240	325	143	399	332	93	220	145	197	15	377	362	197	*	377	252	237	366	125
19-20	194	148	198	180	102	171	105	137	57	232	347	235	214	135	74	221	215	49	90	66	82	49	132	185	110	25	54	107	77	177	25
20-21	49	33	57	53	71	57	21	90	15	135	154	56	62	46	35	89	52	0	33	25	15	0	33	40	0	8	0	5	41	35	0
21-22	0	0	0	8	16	0	0	0	0	25	25	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX

WATTS / SQ. M.

Month: JULY 1979

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 7	0	8	74	82	49	49	41	16	49	*	33	16	33	49	16	49	49	74	66	41	49	41	33	41	8	16	49	8	57	41	33
7- 8	49	56	221	115	221	98	156	74	164	*	82	74	131	164	74	164	197	229	197	147	172	139	164	123	25	66	205	25	188	115	139
8- 9	16	188	401	311	401	377	323	303	295	*	164	262	262	279	270	336	377	410	336	311	328	246	254	279	41	156	287	41	369	262	172
9-10	90	630	573	319	573	557	500	467	410	*	229	536	360	433	541	475	524	557	573	344	500	442	270	451	66	254	377	41	549	475	246
10-11	172	492	737	573	737	729	655	426	655	*	459	647	573	524	664	655	590	754	655	532	647	451	467	598	49	623	467	90	606	655	180
11-12	238	819	229	688	836	852	778	655	737	*	631	680	664	606	770	819	762	819	639	459	754	475	605	647	41	827	745	180	795	754	270
12-13	279	909	377	655	*	918	836	737	852	*	944	754	770	516	852	418	926	845	573	541	352	433	836	713	33	909	516	221	860	827	262
13-14	213	950	385	939	*	950	885	827	737	*	573	778	852	123	434	483	942	918	631	672	877	311	736	688	106	926	631	442	877	893	459
14-15	164	934	328	631	967	868	852	819	737	680	688	696	778	393	795	524	934	860	270	836	844	778	795	688	139	877	311	385	836	705	492
15-16	246	229	385	819	852	721	795	754	762	705	532	557	860	492	688	647	762	811	246	623	770	729	729	655	98	803	442	737	762	664	319
16-17	475	344	164	655	705	672	639	590	698	573	614	524	647	467	688	623	590	688	295	434	647	549	582	565	82	655	475	590	647	410	393
17-18	369	492	500	524	573	532	565	323	426	131	475	500	500	123	557	541	459	524	533	360	492	434	414	426	16	467	254	500	483	254	279
18-19	49	295	213	492	369	377	393	311	262	115	303	323	344	164	336	393	377	328	328	131	303	246	246	254	33	279	172	246	303	139	139
19-20	33	205	246	221	213	229	221	164	131	156	164	180	197	131	213	213	205	147	156	82	147	82	115	90	25	82	74	123	139	57	49
20-21	25	74	106	25	82	66	66	49	56	41	33	57	66	33	66	66	82	25	57	33	25	8	25	25	8	16	25	33	25	4	4
21-22	0	0	8	4	4	4	0	0	16	0	0	4	4	2	6	4	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX

WATTS / SQ. M.

Month: AUGUST 1977

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1- 4	0	0	0	0	0	0	0	0	0	0	2	1	0	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4- 5	0	0	0	0	0	0	0	0	0	0	2	0	0	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*	*	*	*
5- 6	2	2	0	0	2	3	2	2	0	0	2	2	0	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*	*	*	*
6- 7	35	62	25	18	13	109	37	29	103	10	2	84	2	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*	*	*	*
7- 8	185	235	60	156	47	304	203	126	215	40	31	223	56	*	*	*	26	*	*	*	*	*	*	*	*	*	*	*	*	*	*
8- 9	458	232	166	270	60	520	137	414	382	90	335	429	168	*	*	*	106	*	*	*	*	*	*	*	*	*	*	*	*	*	*
9-10	259	72	212	201	97	679	110	339	541	195	629	595	361	*	*	*	179	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10-11	594	56	616	285	109	696	71	703	701	401	776	711	391	*	*	*	448	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11-12	646	156	389	547	200	668	96	704	827	500	858	861	510	*	*	*	532	*	*	*	*	*	*	*	*	*	*	*	*	*	*
12-13	799	123	795	890	702	842	247	861	939	417	673	862	159	*	*	*	495	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13-14	545	259	902	881	367	833	554	699	799	376	695	849	96	*	*	*	925	*	*	*	*	*	*	*	*	*	*	*	*	*	*
14-15	523	328	915	685	588	752	523	336	688	345	541	846	97	*	*	*	842	*	*	*	*	*	*	*	*	*	*	*	*	*	*
15-16	582	173	771	491	439	757	699	721	658	351	394	739	215	*	*	*	128	*	*	*	*	*	*	*	*	*	*	*	*	*	*
16-17	508	57	639	24	536	582	554	429	475	213	301	610	210	*	*	*	141	*	*	*	*	*	*	*	*	*	*	*	*	*	*
17-18	184	82	398	210	194	404	370	416	275	8	433	476	472	*	*	*	363	*	*	*	*	*	*	*	*	*	*	*	*	*	*
18-19	179	46	204	101	154	235	200	217	141	0	210	266	179	*	*	*	175	*	*	*	*	*	*	*	*	*	*	*	*	*	*
19-20	56	12	65	22	18	74	38	59	32	0	21	40	31	*	*	*	45	*	*	*	*	*	*	*	*	*	*	*	*	*	*
20-21	6	7	7	2	2	2	2	2	0	0	2	2	15	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*	*	*	*
21-22	2	2	0	0	0	0	0	0	0	0	0	0	0	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*	*	*	*
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

MINISTRY OF THE ENVIRONMENT

SUBSURFACE ENVIRONMENTAL STUDY

SOLAR FLUX

LANGLEYS / SQ. M.

Month: AUGUST 1978

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1- 4	2	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	13	7	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	2	0	2	0	0	0	0	0	0	0	0	0	2	2	0	0	13	8	0	0	0	0	0	0	0	0	0	0	0	0	8
5- 6	36	30	39	33	16	28	25	16	16	16	0	0	2	3	0	0	13	10	0	0	0	0	0	0	0	0	0	8	0	0	8
6- 7	110	159	162	164	151	92	131	133	136	144	116	21	15	2	13	0	25	25	0	8	16	8	0	0	0	8	0	0	0	0	8
7- 8	230	284	343	341	328	274	295	282	317	318	303	133	100	87	100	12	57	118	16	126	112	107	39	8	59	57	74	0	8	85	98
8- 9	282	413	523	523	508	476	484	449	492	483	476	287	267	156	246	164	49	295	98	312	299	279	103	44	102	205	123	4	82	230	279
9-10	668	451	689	554	669	599	574	636	656	656	625	464	443	353	397	184	164	472	230	476	472	464	57	112	148	338	284	16	148	415	459
10-11	684	558	807	754	779	489	705	758	771	730	763	627	577	586	485	397	344	640	180	640	615	618	115	141	177	200	508	59	430	571	607
11-12	677	400	884	886	853	508	807	836	590	836	861	681	705	700	604	331	574	656	115	774	730	705	123	210	213	289	707	246	722	640	738
12-13	654	148	774	869	830	558	804	856	895	864	771	754	627	782	779	413	469	792	115	353	804	754	87	253	299	377	689	82	686	718	804
13-14	618	131	810	512	776	656	705	830	799	853	853	779	777	805	800	561	653	820	221	866	820	639	57	154	230	213	722	249	713	869	820
14-15	736	49	846	620	730	623	763	722	525	771	768	651	564	766	771	505	597	833	161	836	794	505	57	189	161	213	563	590	394	820	786
15-16	679	16	499	549	551	705	653	607	394	648	664	687	157	689	620	477	640	649	265	746	705	135	66	177	131	490	325	443	353	697	688
16-17	331	41	512	290	374	323	479	315	153	492	492	538	372	561	420	323	574	492	177	610	590	230	66	118	192	410	228	377	518	594	524
17-18	348	16	325	148	344	246	303	135	148	312	313	335	400	402	317	110	423	148	108	459	413	131	43	126	312	274	115	262	239	312	352
18-19	172	8	146	102	156	123	135	49	115	131	136	266	203	246	221	36	328	136	36	279	246	177	0	57	225	131	51	54	213	243	197
19-20	36	0	43	16	30	33	16	0	16	15	21	102	80	94	37	12	110	32	30	94	57	65	0	8	82	46	8	0	59	66	33
20-21	0	0	0	0	0	0	0	0	0	0	0	3	7	8	5	3	13	8	0	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX

WATTS / SQ. M.

Month: AUGUST 1979

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 7	49	0	41	8	0	41	0	0	57	0	49	33	0	0	123	0	0	0	0	*	0	57	0	0	0	0	0	0	0	*	*
7- 8	180	0	147	106	105	172	0	164	155	49	172	164	0	0	135	102	70	0	0	*	0	327	33	0	41	0	0	25	15	*	*
8- 9	352	16	328	336	237	360	49	352	352	123	311	344	164	155	543	279	213	0	0	475	57	410	93	41	78	0	258	237	27	*	*
9-10	524	57	492	516	311	530	57	524	549	393	541	500	130	174	756	393	397	0	164	496	147	573	129	145	389	442	393	330	51	*	*
10-11	664	82	631	696	532	614	66	680	655	369	655	754	90	238	821	502	467	23	143	655	156	696	190	106	553	593	317	287	82	*	*
11-12	803	279	532	680	623	819	66	786	827	254	672	836	90	215	793	688	604	72	246	721	467	776	110	106	694	683	229	164	178	*	*
12-13	795	213	557	664	672	819	106	827	819	623	786	983	74	162	819	696	682	92	592	797	819	838	109	371	797	706	436	162	78	*	*
13-14	770	123	385	683	860	819	139	868	819	106	754	934	115	188	903	707	725	162	715	674	809	846	113	680	453	741	498	578	41	*	*
14-15	655	197	492	508	827	713	98	827	811	115	705	721	131	203	850	786	850	188	698	59	754	705	104	266	272	596	236	678	203	*	*
15-16	713	688	467	352	655	721	3	737	623	172	688	729	115	160	686	700	532	174	614	113	635	512	63	715	205	580	66	492	113	*	*
16-17	557	573	606	336	590	623	270	655	401	172	631	573	*	86	633	578	106	133	635	307	475	496	45	604	*	416	88	160	123	*	*
17-18	475	524	410	213	451	549	467	557	229	147	516	524	*	20	510	471	160	121	598	139	313	340	57	401	*	317	66	172	82	*	*
18-19	188	377	336	98	328	328	327	335	147	197	426	336	*	0	253	225	75	106	598	96	133	186	29	143	*	205	20	119	82	*	*
19-20	82	197	147	57	164	197	130	205	74	188	213	139	*	0	170	115	82	86	553	20	20	63	15	20	*	0	0	43	20	*	*
20-21	41	74	57	0	57	57	57	57	0	57	66	41	*	0	37	37	27	41	283	0	0	0	0	0	*	0	0	0	0	*	*
21-22	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	150	0	0	0	0	0	*	0	0	0	0	*	*
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

FACILITY OF THE ENVIRONMENT

SOLEDUY ENVIRONMENTAL STUDY

SOLAR FLUX

WATTS / SQ. M.

Month: SEPTEMBER 1975

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7- 8	49	25	8	57	74	33	8	66	57	0	0	33	41	8	33	49	8	16	25	0	8	33	33	33	25	16	0	16	0	0
8- 9	147	98	57	238	246	57	33	156	238	33	16	98	229	16	221	213	57	33	106	0	33	205	197	147	82	49	0	156	25	0
9-10	401	319	172	426	451	74	74	295	418	66	65	172	418	33	393	279	131	66	295	8	74	393	410	131	344	279	49	352	57	8
10-11	598	516	246	265	598	66	82	451	588	131	66	295	573	43	491	328	229	74	197	115	98	532	459	319	541	196	98	475	123	25
11-12	705	647	360	688	631	82	287	623	688	123	106	467	688	98	393	311	410	90	279	156	164	721	492	164	655	123	139	614	246	33
12-13	770	713	639	754	688	90	451	655	762	147	74	754	745	66	377	246	434	90	323	147	130	754	565	229	623	147	139	639	164	33
13-14	778	631	901	762	737	115	590	680	770	106	180	655	770	41	393	270	418	115	229	82	172	762	631	393	557	164	180	672	164	16
14-15	590	197	836	721	721	180	770	713	705	90	156	713	737	41	377	393	393	131	295	33	164	279	623	573	664	172	262	344	180	25
15-16	459	66	713	279	623	172	655	664	434	147	279	623	492	49	139	369	434	115	377	213	115	492	532	459	565	106	492	319	106	25
16-17	270	49	565	115	262	49	549	467	115	123	139	475	352	41	278	459	377	66	377	57	32	426	459	434	451	49	426	360	49	16
17-18	328	33	360	57	279	33	360	279	131	49	16	297	295	8	57	295	131	98	246	33	82	262	270	213	270	16	238	205	41	8
18-19	131	16	205	49	123	57	123	180	16	8	8	115	82	0	25	115	82	33	82	8	25	92	66	82	82	16	66	41	25	0
19-20	25	25	49	41	25	25	16	25	8	0	0	16	0	0	0	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0
20-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX

WATTS / SQ. F.

Month: OCTOBER 197.

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7- 8	0	25	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	82	16	49
8- 9	57	115	25	131	41	16	57	57	32	16	106	90	41	8	123	98	90	0	16	25	49	33	16	41	33	16	8	164	262	41	123
9-10	66	311	49	213	115	41	139	90	139	49	254	213	205	106	319	262	115	16	33	213	147	66	49	98	49	115	66	323	393	66	147
10-11	131	475	74	295	90	205	229	303	323	57	393	385	442	295	475	418	147	25	49	328	197	123	123	131	25	156	139	426	459	229	371
11-12	213	573	90	246	115	270	344	279	393	221	491	475	233	451	524	500	188	49	41	377	328	295	197	156	25	180	197	229	500	426	508
12-13	172	573	115	213	98	237	377	237	410	303	557	606	238	418	590	582	336	33	57	475	377	426	344	66	25	98	131	278	508	508	549
13-14	238	524	82	246	74	123	360	442	623	205	565	598	237	451	590	606	238	66	*	410	475	344	557	66	16	74	90	180	467	442	475
14-15	221	541	41	229	106	139	377	492	557	106	492	467	590	221	573	565	147	98	82	623	410	369	557	197	16	66	98	115	369	352	369
15-16	328	344	33	180	98	115	238	475	475	74	369	369	434	238	442	434	57	16	66	410	623	246	475	90	33	98	33	82	238	229	229
16-17	361	188	41	229	74	66	197	377	344	57	180	262	156	131	311	319	49	24	49	279	410	98	279	57	16	33	50	49	82	74	74
17-18	229	115	0	139	57	33	123	205	164	25	90	115	90	74	172	156	33	8	33	123	270	49	123	33	0	0	16	8	0	0	0
18-19	33	16	0	16	49	0	16	33	25	0	0	16	0	0	0	0	8	0	8	25	123	0	16	0	0	0	0	0	0	0	0
19-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX

LANGLEYS / SQ. CM.

Month: NOVEMBER 1971

HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7- 8	16	25	16	16	0	0	33	15	0	0	0	16	0	0	15	15	0	0	15	8	33	8	0	0	16	8	0	0	0	8
8- 9	180	139	82	139	16	33	172	93	16	8	16	115	33	0	92	25	41	16	106	66	115	49	0	41	82	82	33	33	33	82
9-10	295	279	155	221	90	115	279	254	49	33	41	180	147	0	183	66	49	49	262	252	295	131	0	74	164	156	98	147	180	213
10-11	401	393	311	262	229	197	365	352	106	33	33	229	123	16	360	123	66	74	287	279	401	221	57	180	229	246	172	221	279	319
11-12	467	410	442	197	401	180	442	418	156	66	49	360	57	82	246	229	16	98	475	524	425	344	66	172	137	295	180	295	262	377
12-13	475	410	451	426	385	344	459	541	164	74	123	393	49	139	139	229	16	49	323	475	295	235	66	147	180	323	221	328	115	336
13-14	393	393	410	377	369	197	410	237	172	25	131	279	16	138	74	344	8	74	395	336	180	172	74	139	164	295	164	311	98	344
14-15	270	295	319	311	197	164	328	180	147	8	66	180	8	303	49	246	0	131	213	270	147	123	66	66	115	180	98	213	25	246
15-16	205	197	197	205	66	90	213	139	74	0	33	82	16	82	0	123	0	82	82	123	49	41	57	33	49	66	33	66	0	115
16-17	90	66	74	74	16	33	66	82	16	0	8	8	0	0	0	33	0	0	16	25	0	8	0	0	8	8	0	0	0	16
17-18	0	8	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* - unavailable data

MINISTRY OF THE ENVIRONMENT

SURFACE ENVIRONMENTAL STUDY

SOLAR FLUX

LANGLEY / CAL. T.

Month: DECEMBER 1971

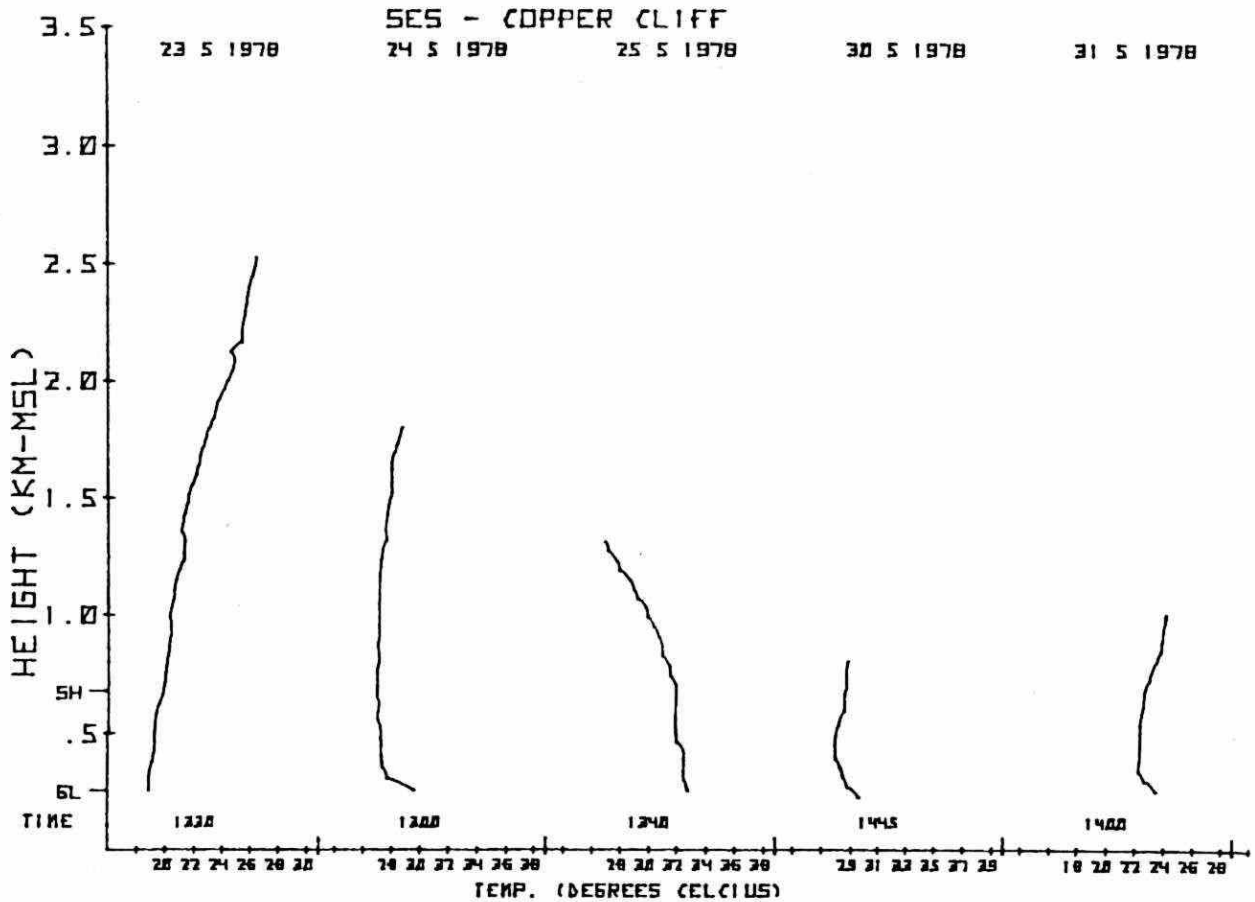
HOUR	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7- 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8- 9	49	33	0	0	0	57	*	*	0	33	41	0	0	0	0	49	0	0	0	0	49	0	0	0	0	0	0	25	0	0	0
9-10	172	115	8	49	82	106	*	*	49	156	138	25	8	74	0	98	49	49	107	33	213	8	148	66	49	57	82	139	25	25	33
10-11	147	164	25	106	57	246	*	*	164	133	320	66	90	156	49	197	131	130	190	73	361	33	336	98	82	140	229	246	74	66	66
11-12	164	197	25	164	147	352	*	*	344	254	230	107	123	229	82	213	131	131	221	172	426	156	311	180	123	238	295	262	82	82	82
12-13	197	213	16	188	229	369	*	*	361	262	385	205	143	213	148	233	148	148	238	156	385	90	336	172	131	328	311	295	115	98	90
13-14	123	221	8	156	164	*	*	*	323	262	197	197	131	197	107	221	98	139	221	98	287	98	311	180	156	303	311	295	98	180	82
14-15	74	197	8	115	74	*	*	*	148	262	139	107	123	131	90	98	82	188	180	82	131	90	246	90	98	254	287	254	82	90	66
15-16	33	115	0	0	25	*	*	*	115	180	49	41	66	57	33	33	41	123	73	25	41	57	82	33	8	82	98	197	25	41	16
16-17	0	16	0	0	0	*	*	*	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	41	0	0	0
17-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

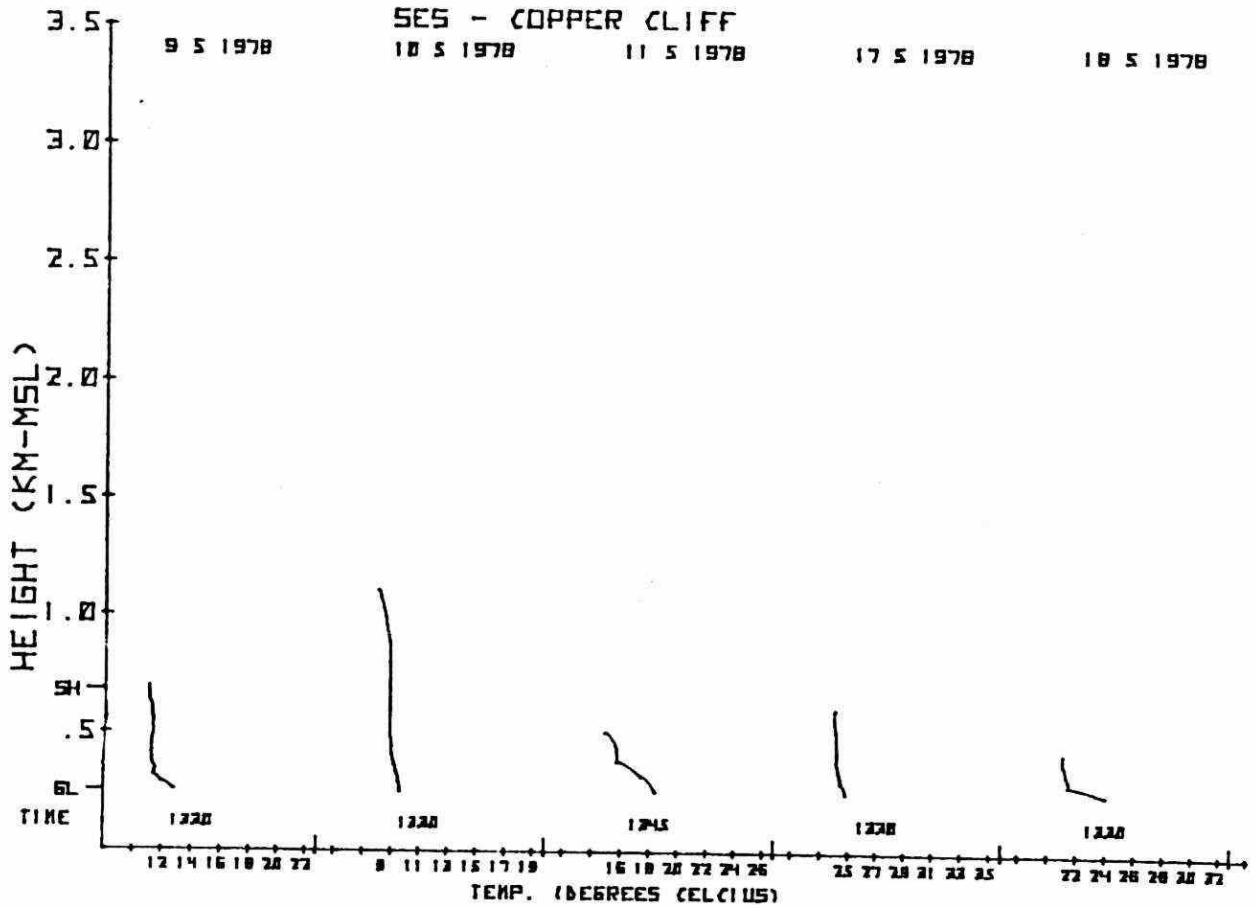
* - unavailable data

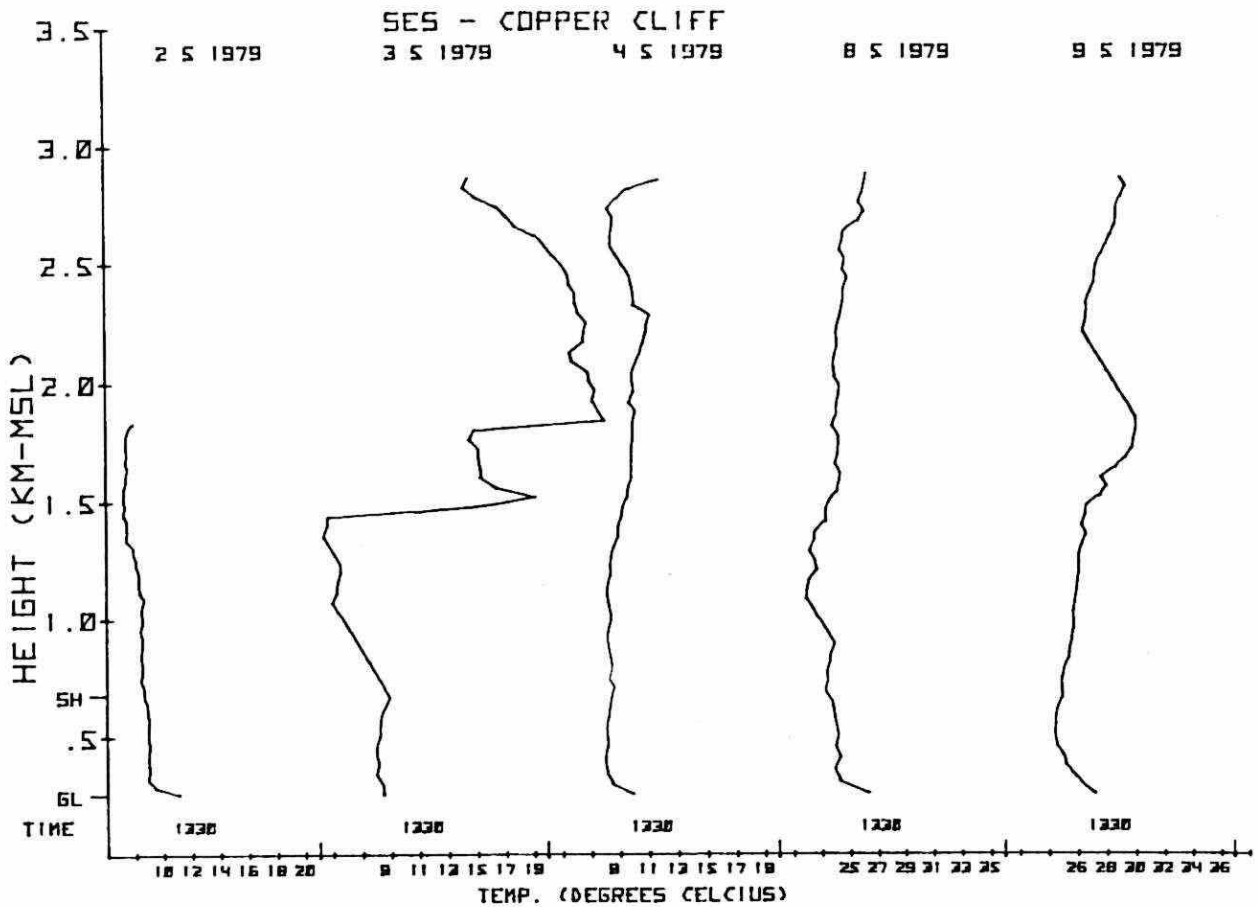
Appendix 4

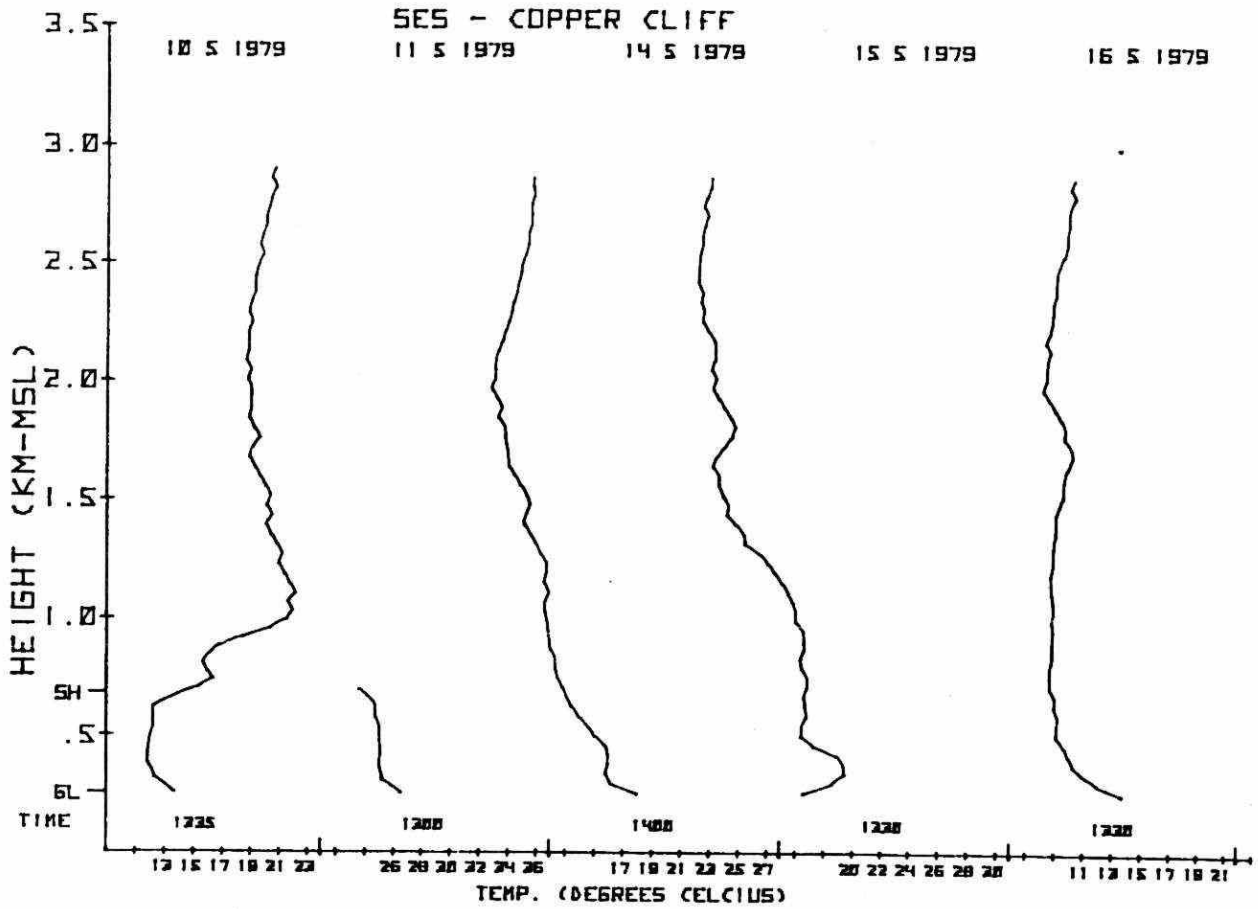
Potential Temperature Profile Plots

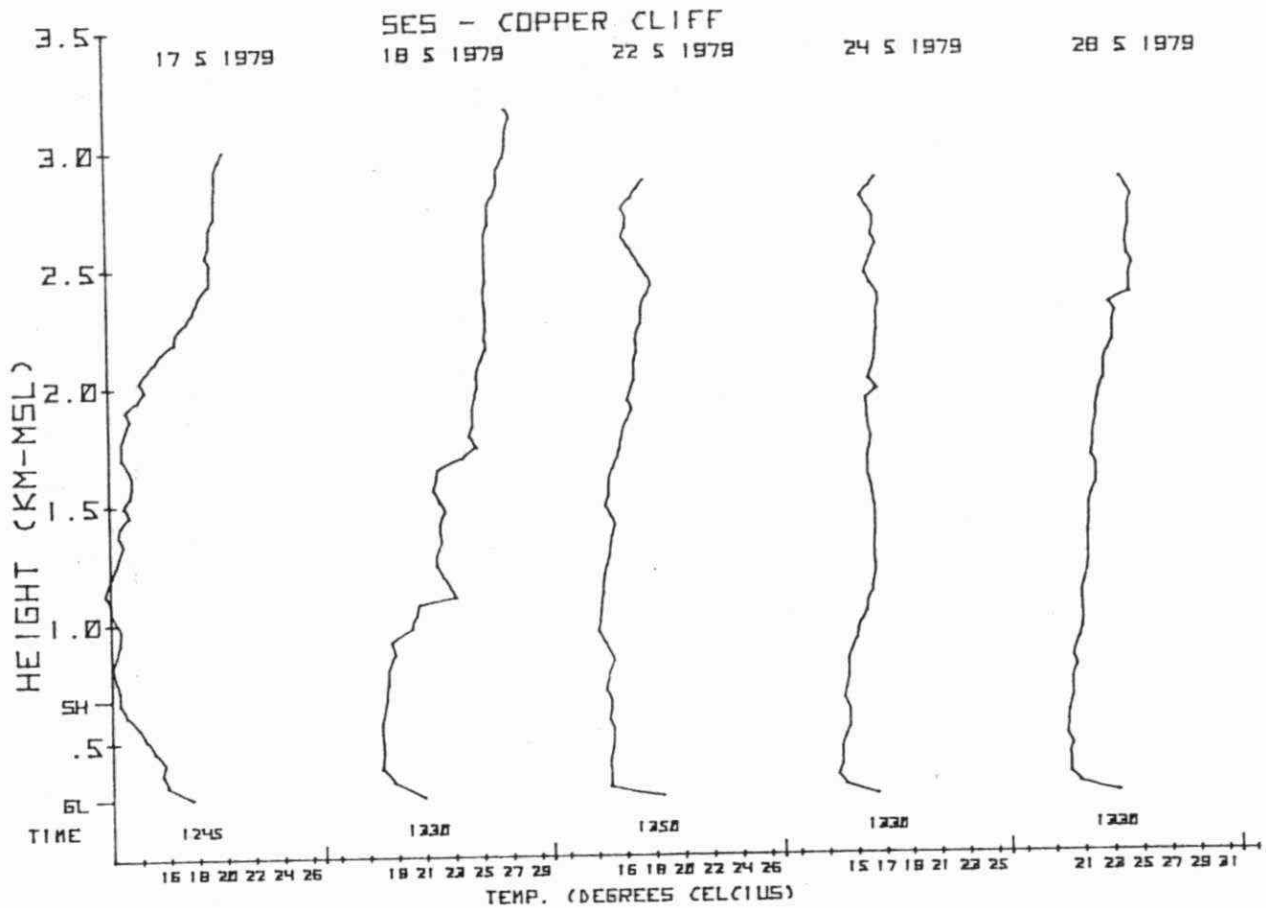
May to September, 1977 to 1979

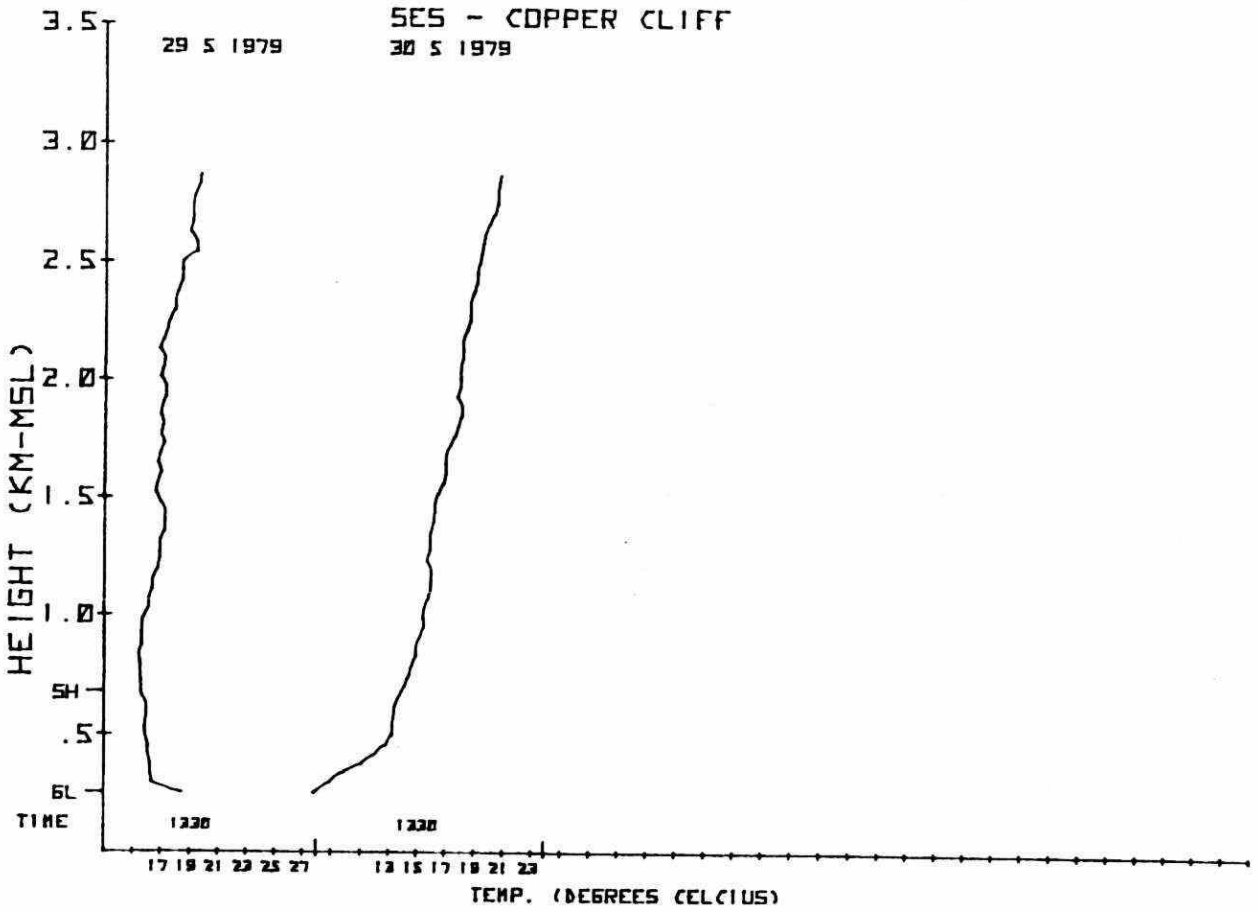

SES - COPPER CLIFF
23 5 1978
24 5 1978
25 5 1978
30 5 1978
31 5 1978
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1330
1300
1340
1445
1400
TEMP. (DEGREES CELCIUS)

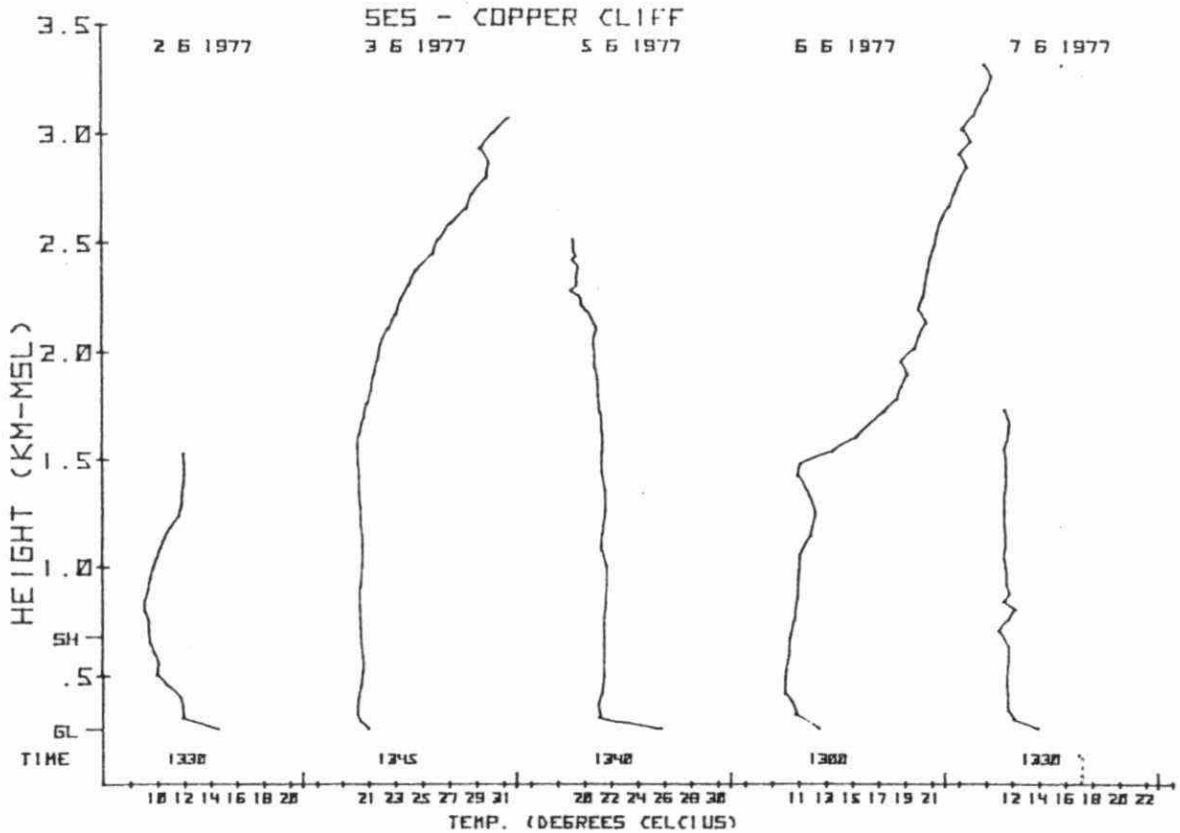

SES - COPPER CLIFF
9 5 1978
10 5 1978
11 5 1978
17 5 1978
18 5 1978
HEIGHT (KM-MSL)
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
TIME
1330
1330
1345
1230
1330
TEMP. (DEGREES CELCIUS)

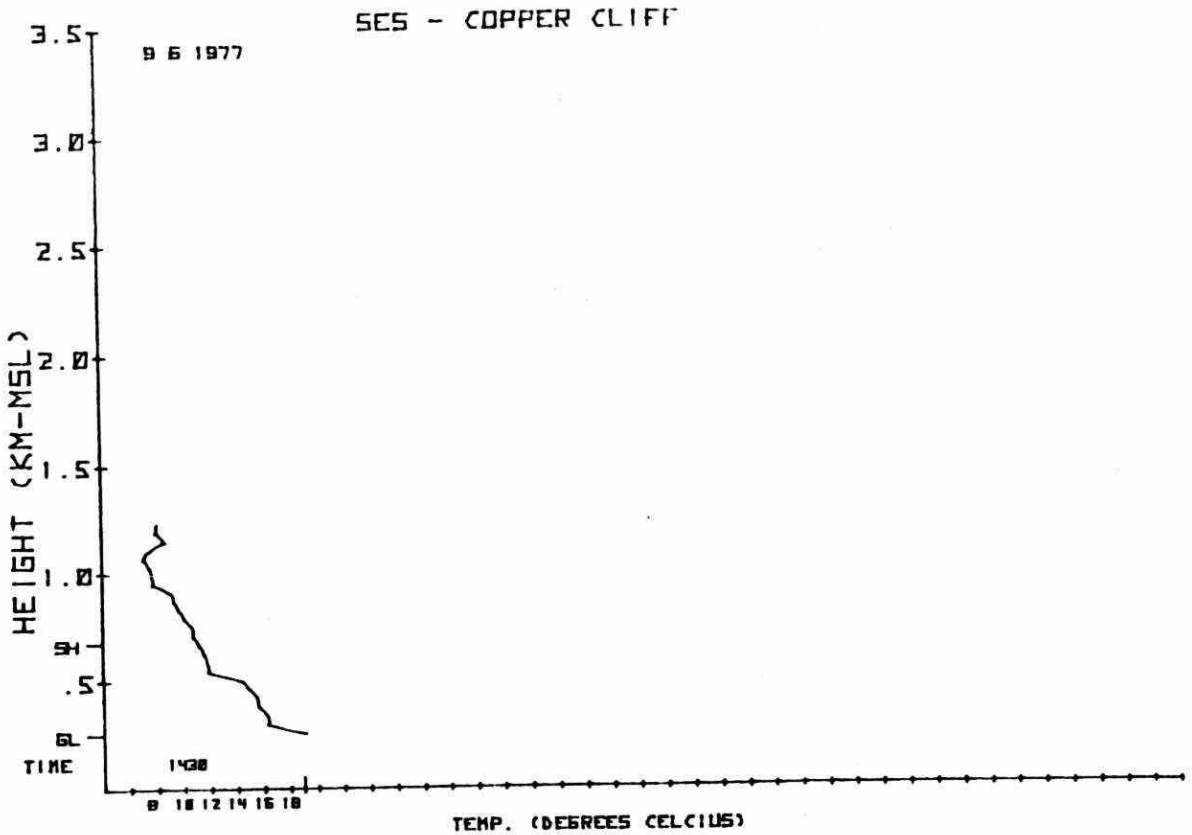

SES - COPPER CLIFF
2 S 1979
3 S 1979
4 S 1979
8 S 1979
9 S 1979
HEIGHT (KM-MSL)
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
TIME
1330
1330
1330
1330
1330
10 12 14 16 18 20
8 11 13 15 17 19
8 11 13 15 17 19
25 27 29 31 33 35
26 28 30 32 34 36
TEMP. (DEGREES CELCIUS)

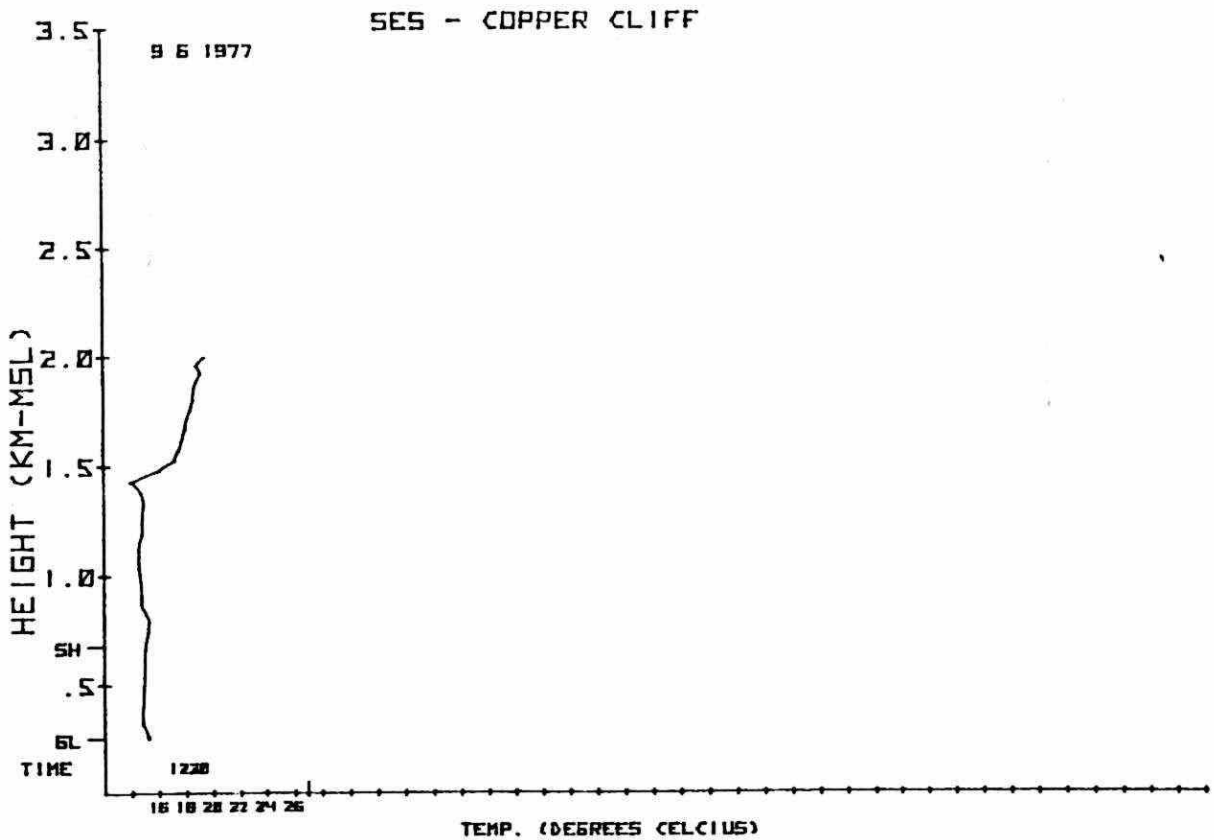

SES - COPPER CLIFF
10 5 1979
11 5 1979
14 5 1979
15 5 1979
16 5 1979
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1235
1308
1408
1238
1328
12 14 16 18 20 22
26 28 30 32 34 36
16 18 20 22 24 26
20 22 24 26 28 30
10 12 14 16 18 20
TEMP. (DEGREES CELCIUS)

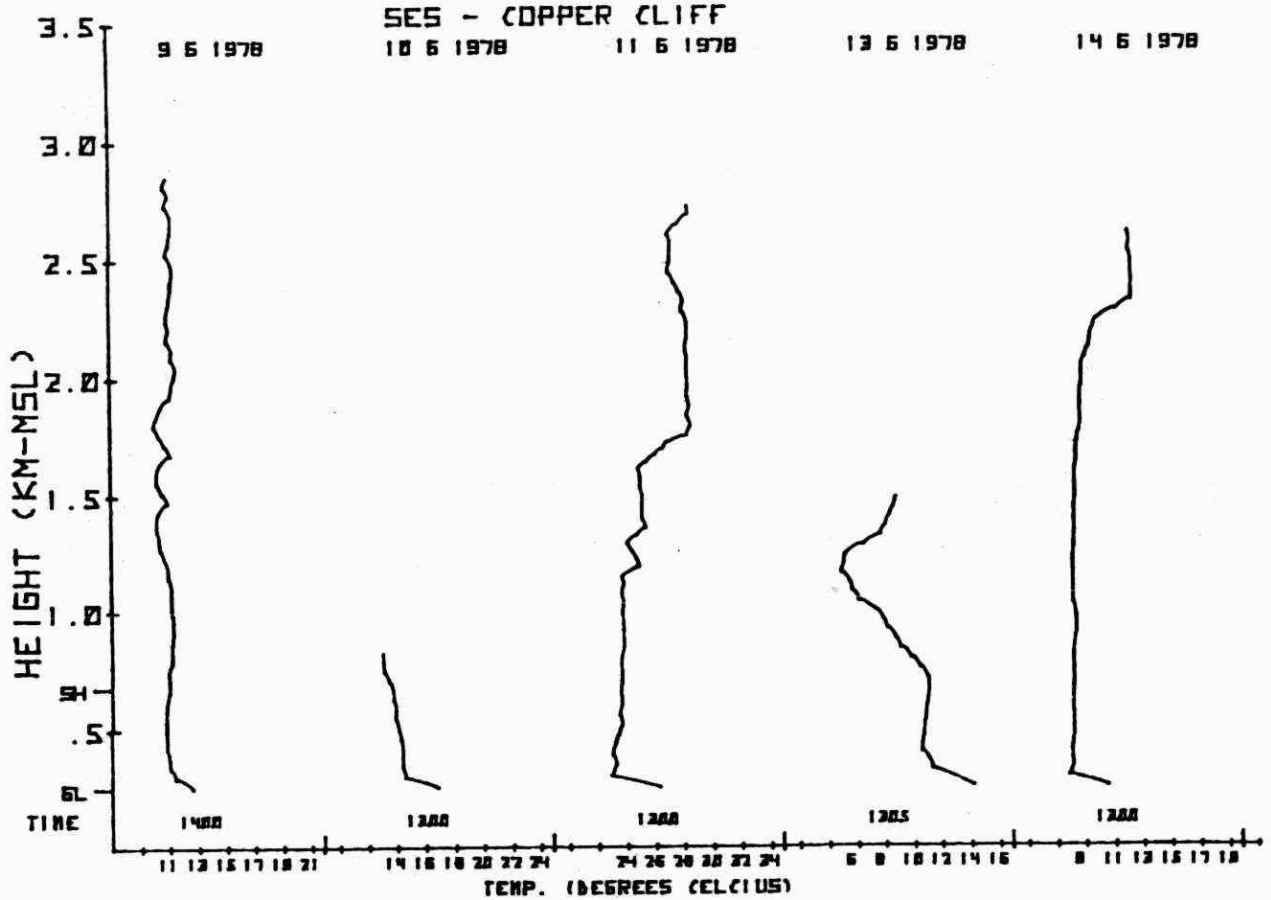

SES - COPPER CLIFF
17 S 1979
18 S 1979
22 S 1979
24 S 1979
28 S 1979
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1245
1330
1350
1330
1330
16 18 20 22 24 26
18 21 23 25 27 29
16 18 20 22 24 26
15 17 19 21 23 25
21 23 25 27 29 31
TEMP. (DEGREES CELCIUS)

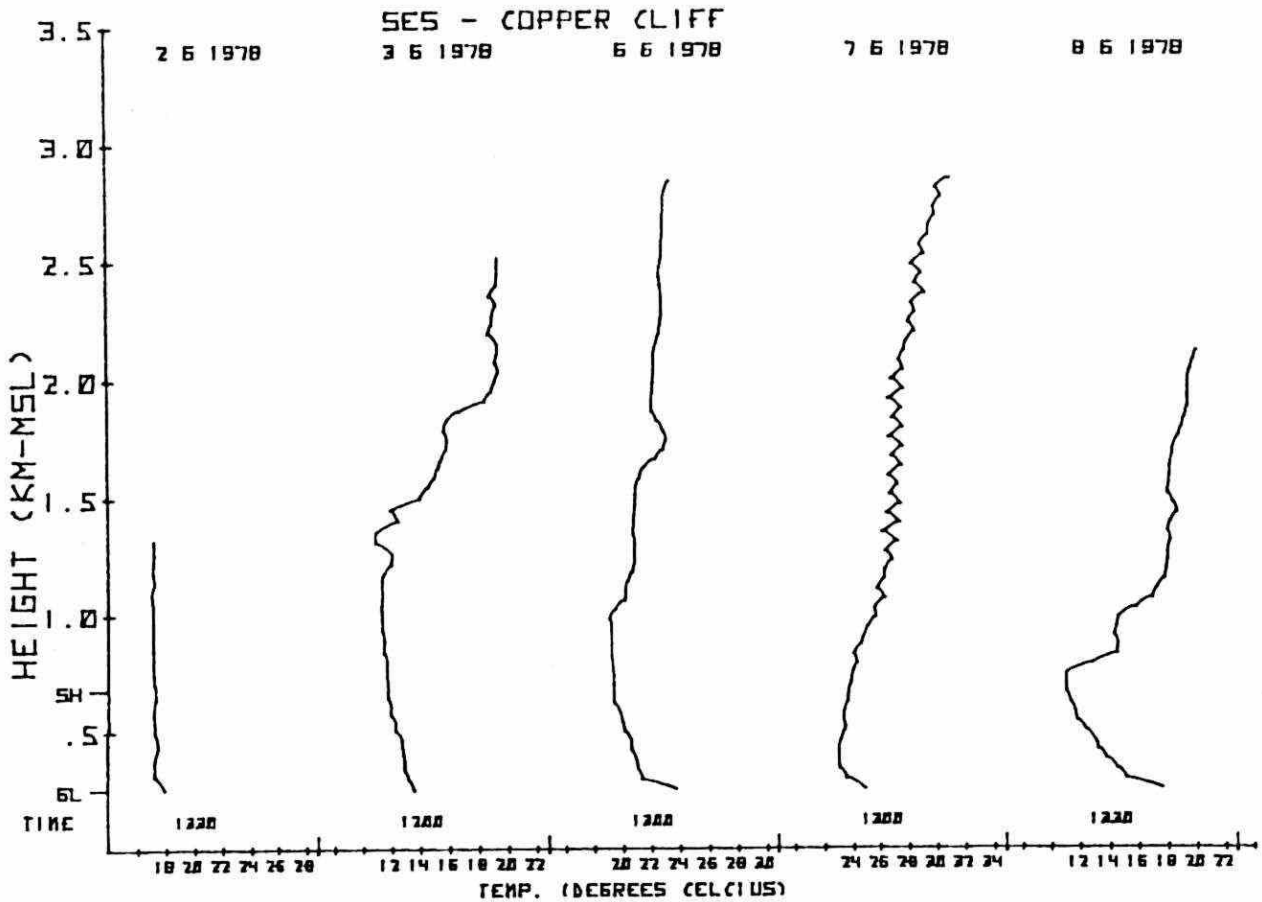

SES - COPPER CLIFF
29 S 1979
30 S 1979
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1330
1330
17 19 21 23 25 27
13 15 17 19 21 23
TEMP. (DEGREES CELCIUS)

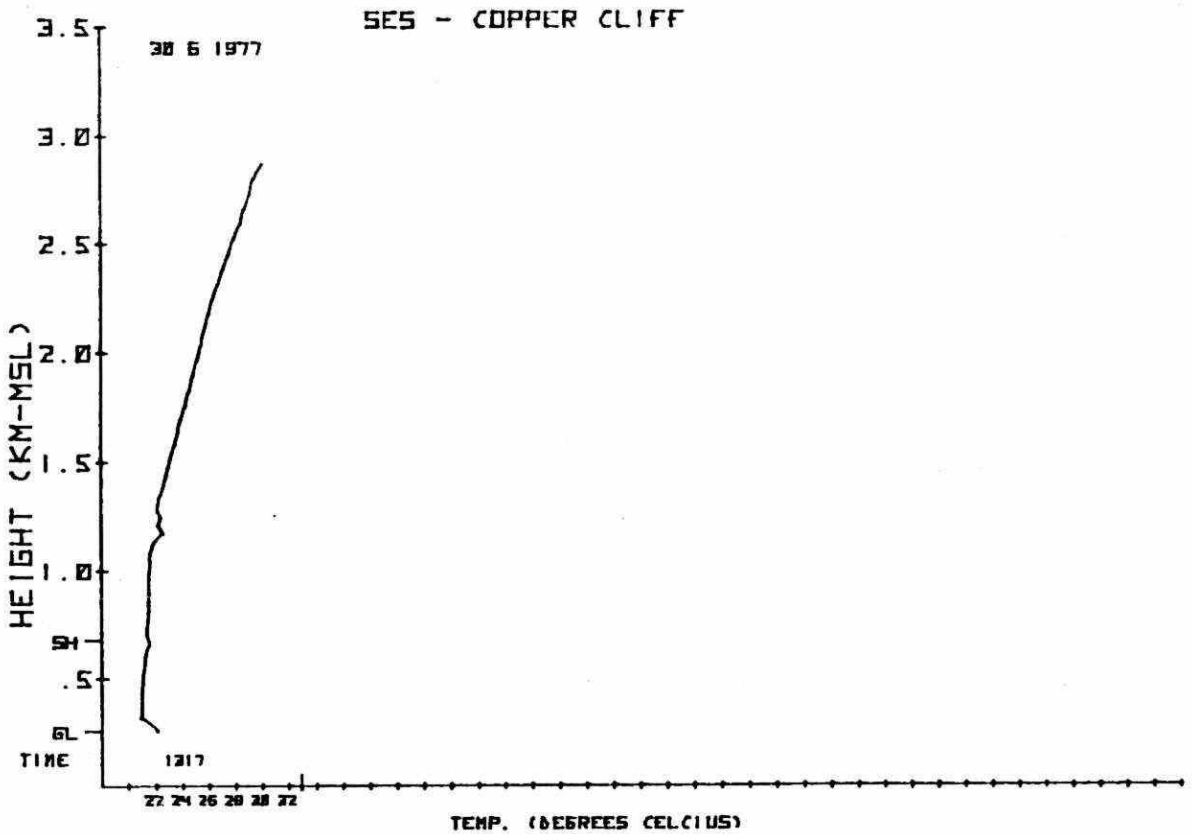

SES - COPPER CLIFF
2 6 1977
3 6 1977
5 6 1977
6 6 1977
7 6 1977
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1330
1245
1340
1300
1330
10 12 14 16 18 20
21 23 25 27 29 31
28 22 24 26 28 30
11 13 15 17 19 21
12 14 16 18 20 22
TEMP. (DEGREES CELCIUS)

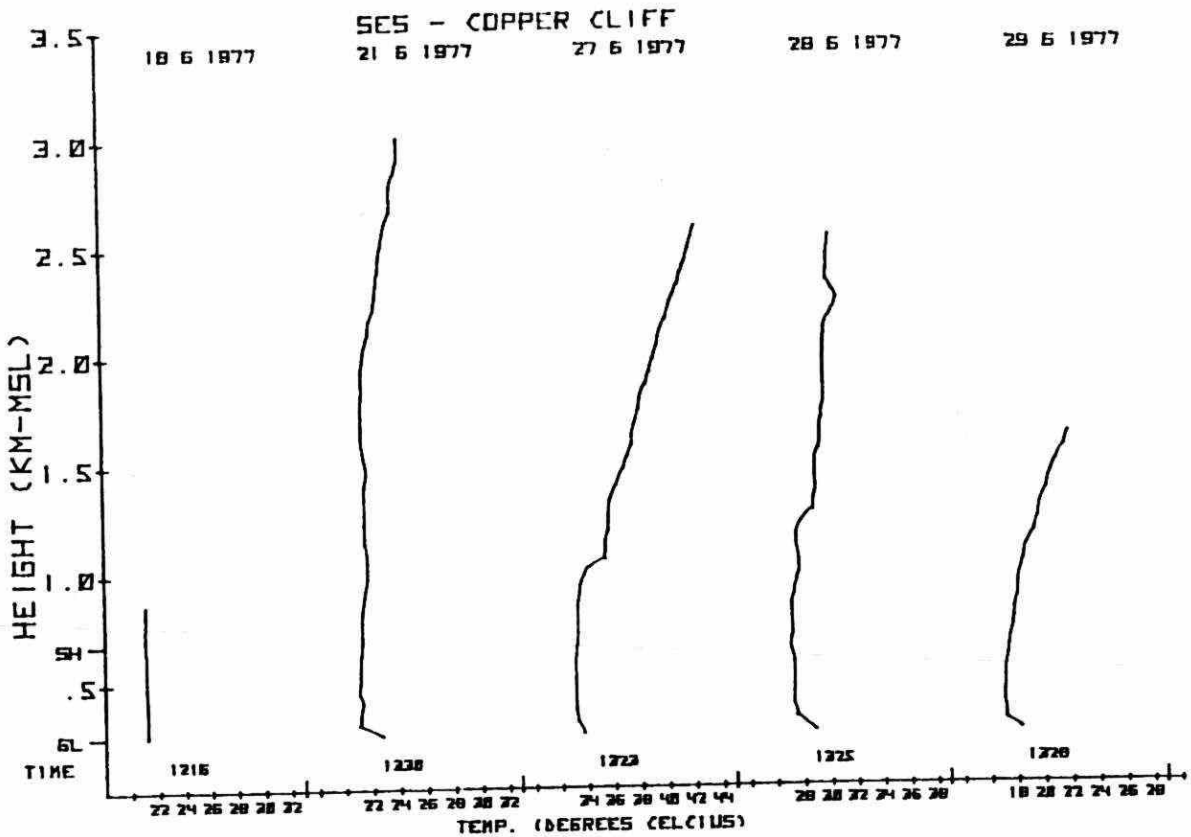

SES - COPPER CLIFF
9 6 1977
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1430
8 10 12 14 16 18
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
9 6 1977
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1220
16 18 20 22 24 26
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
9 6 1978
10 6 1978
11 6 1978
13 6 1978
14 6 1978
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
2 6 1978
3 6 1978
6 6 1978
7 6 1978
8 6 1978
HEIGHT (KM-MSL)
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
TIME
1200
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
30 6 1977
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1317
22 24 26 28 30 32
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
18 6 1977
21 6 1977
27 6 1977
28 6 1977
29 6 1977
3.5
3.0
2.5
2.0
1.5
1.0
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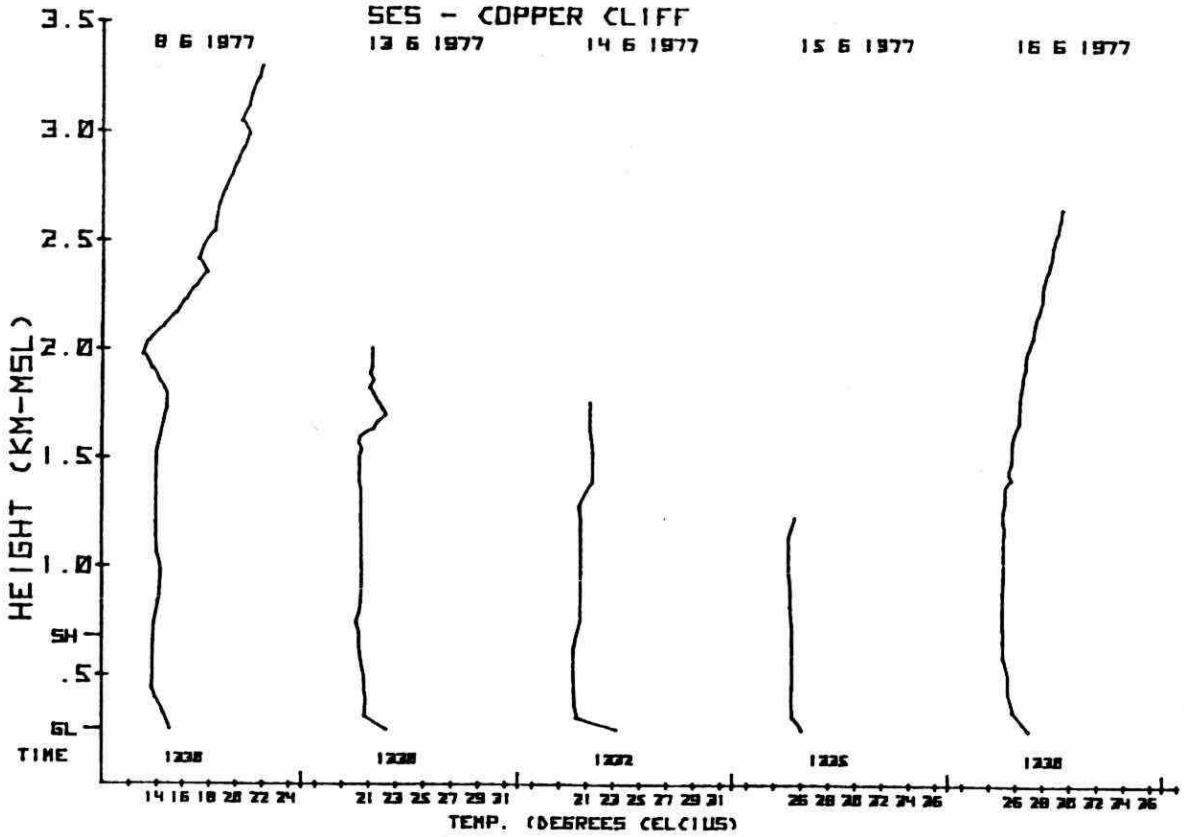
GL
HEIGHT (KM-MSL)
TIME
1216
1238
1723
1725
1729
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1238
1228
1202
1235
1238
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21 23 25 27 29 31
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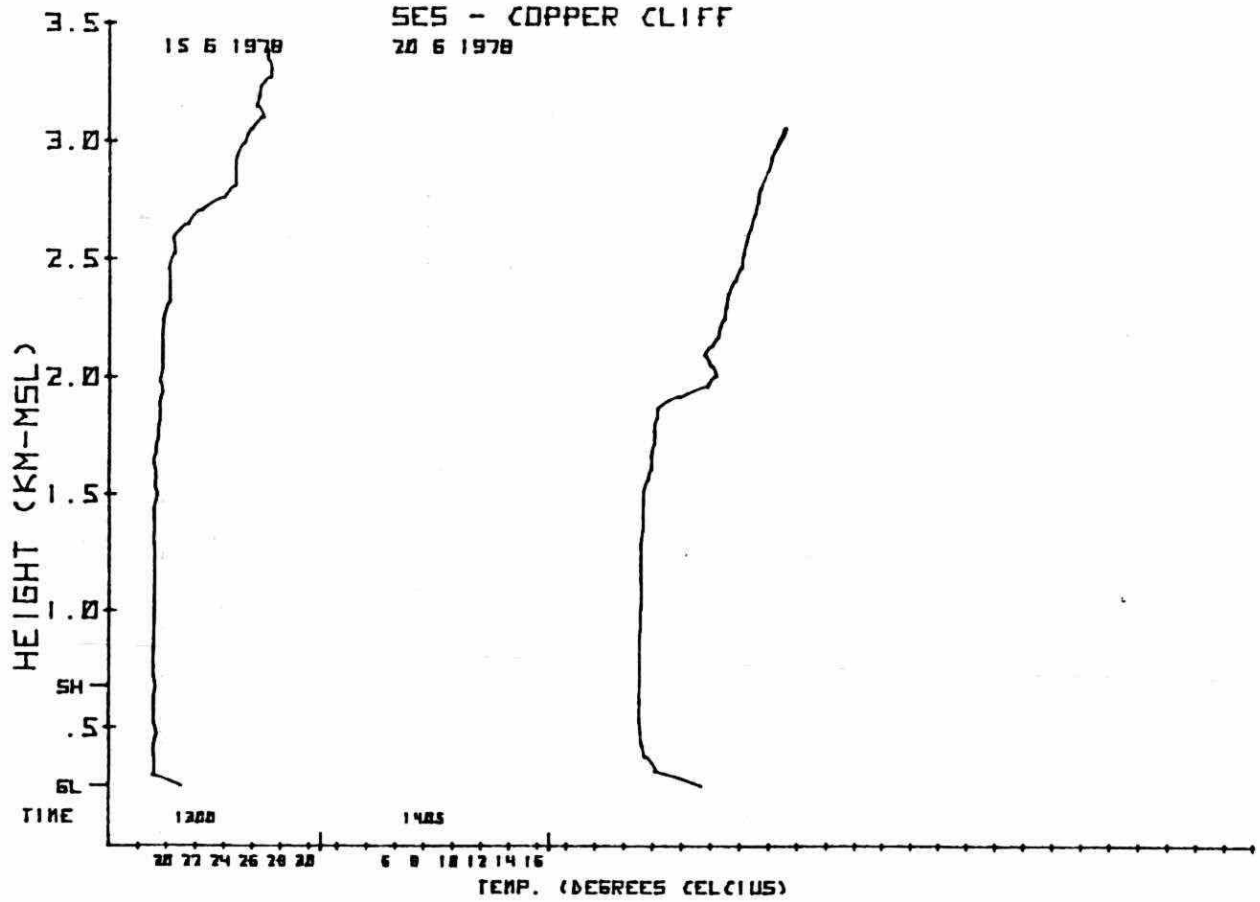
26 28 30 32 34 36
TEMP. (DEGREES CELCIUS)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1.5
1.0
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HEIGHT (KM-MSL)
TIME
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1485
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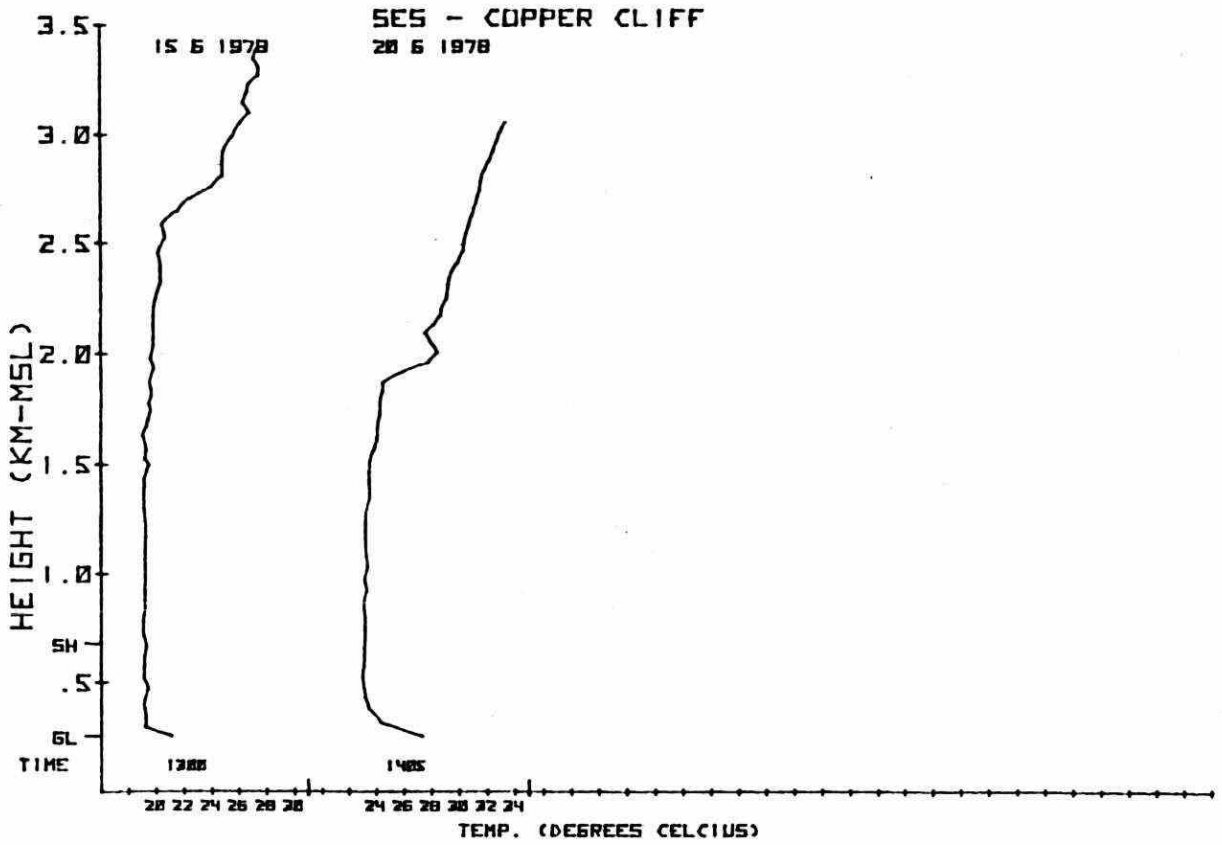
6 8 10 12 14 16
TEMP. (DEGREES CELCIUS)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2.0
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1.0
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HEIGHT (KM-MSL)
TIME
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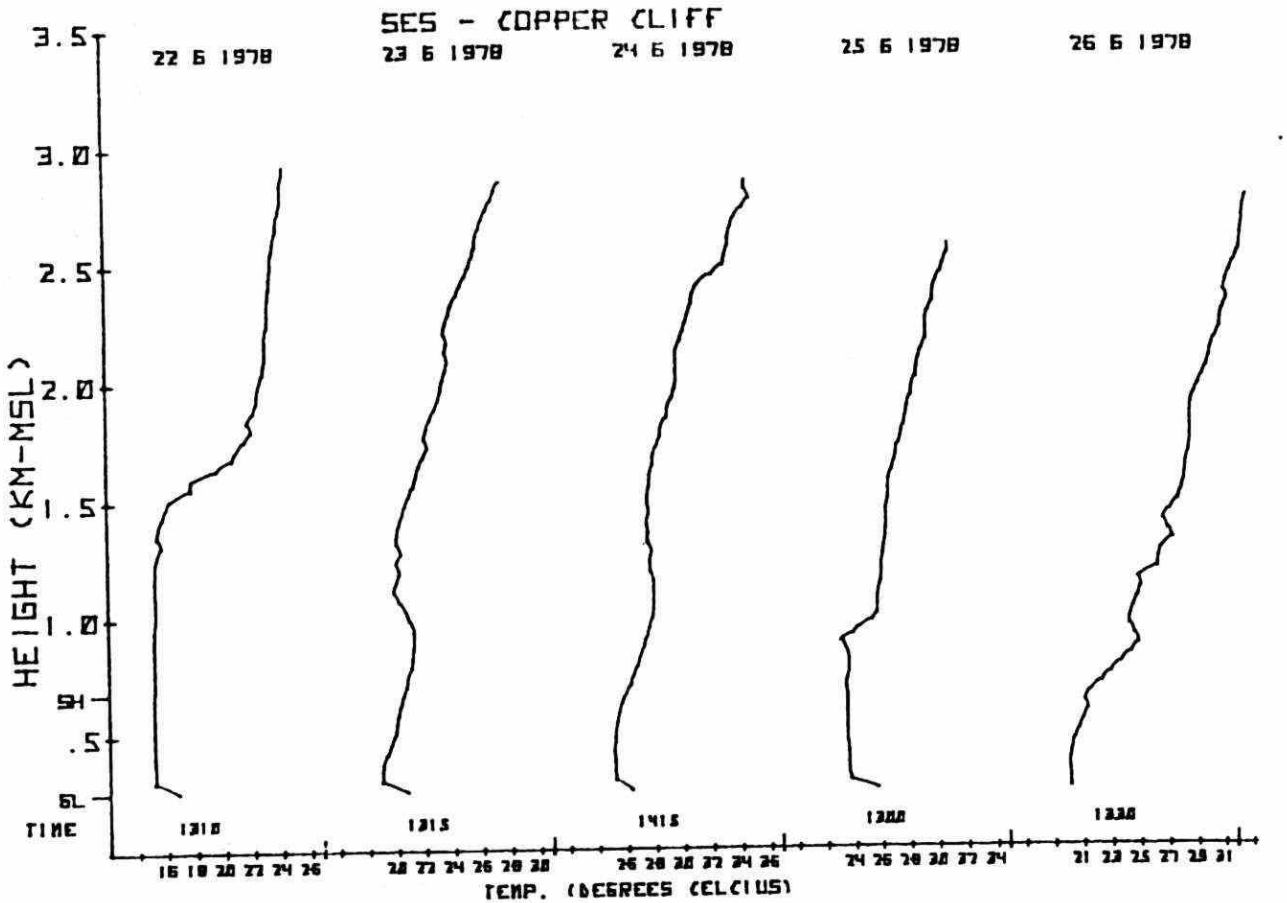
24 26 28 30 32 34
TEMP. (DEGREES CELCIUS)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HEIGHT (KM-MSL)
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TIME
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1415
1300
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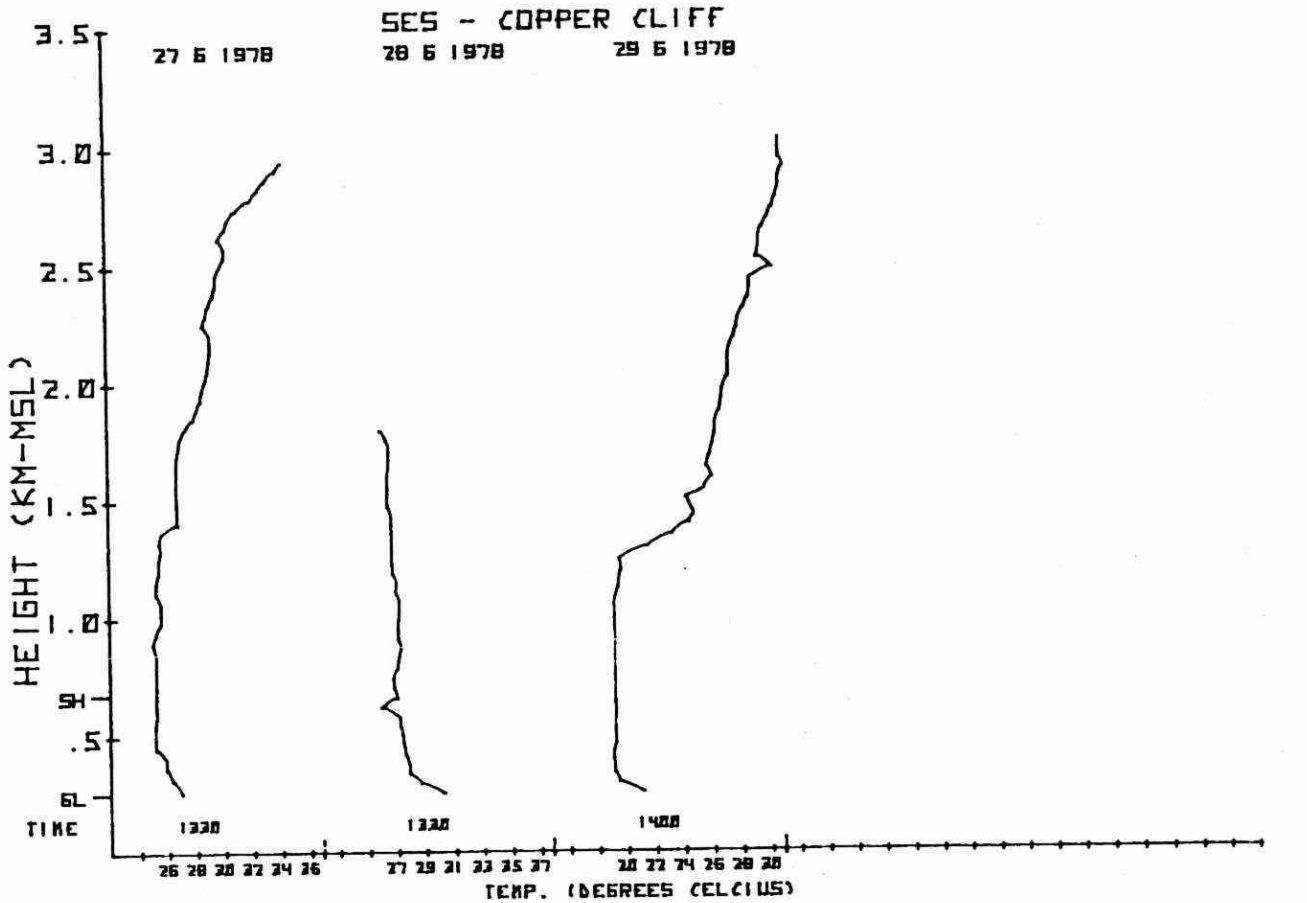
TEMP. (DEGREES CELCIUS)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SH
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GL
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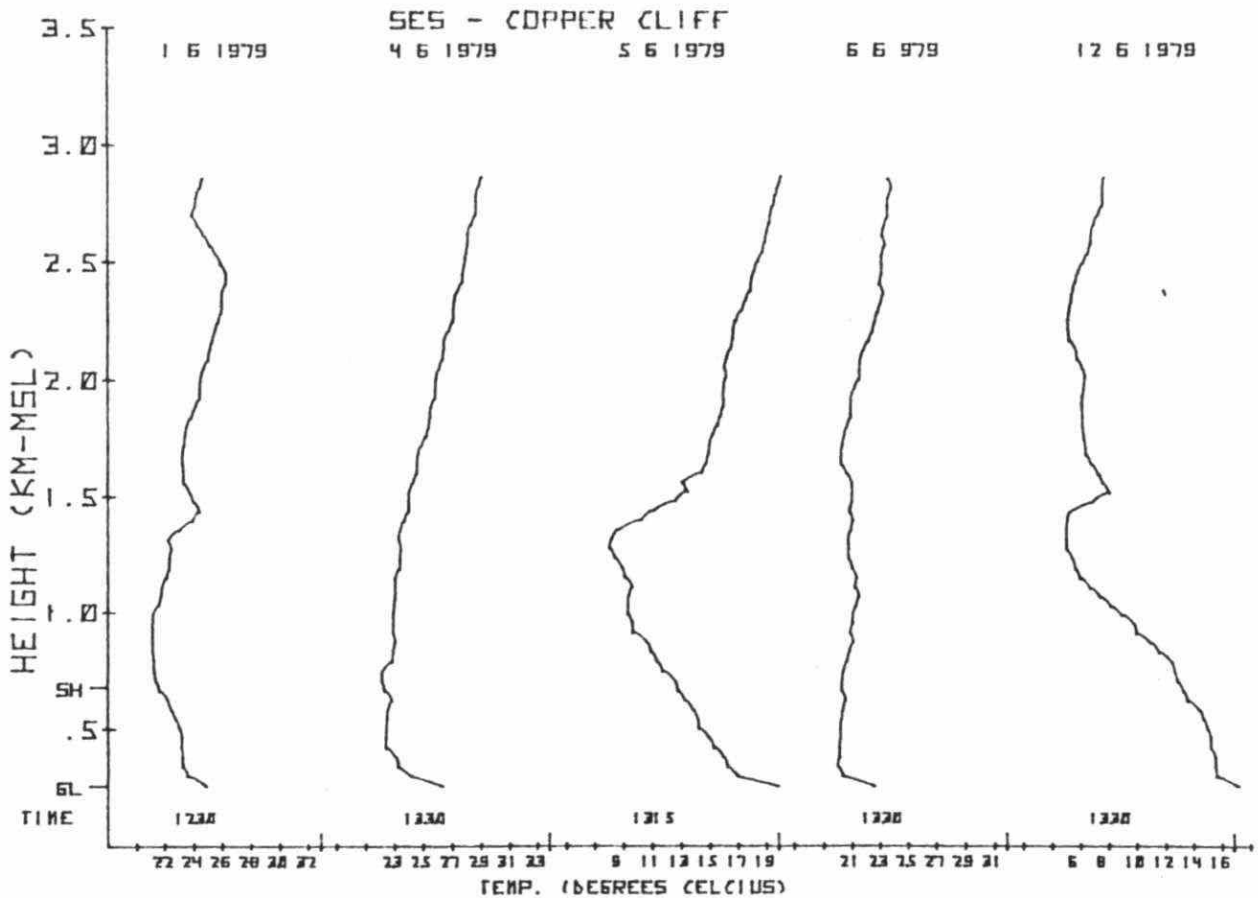
TEMP. (DEGREES CELCIUS)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2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1230
1330
1315
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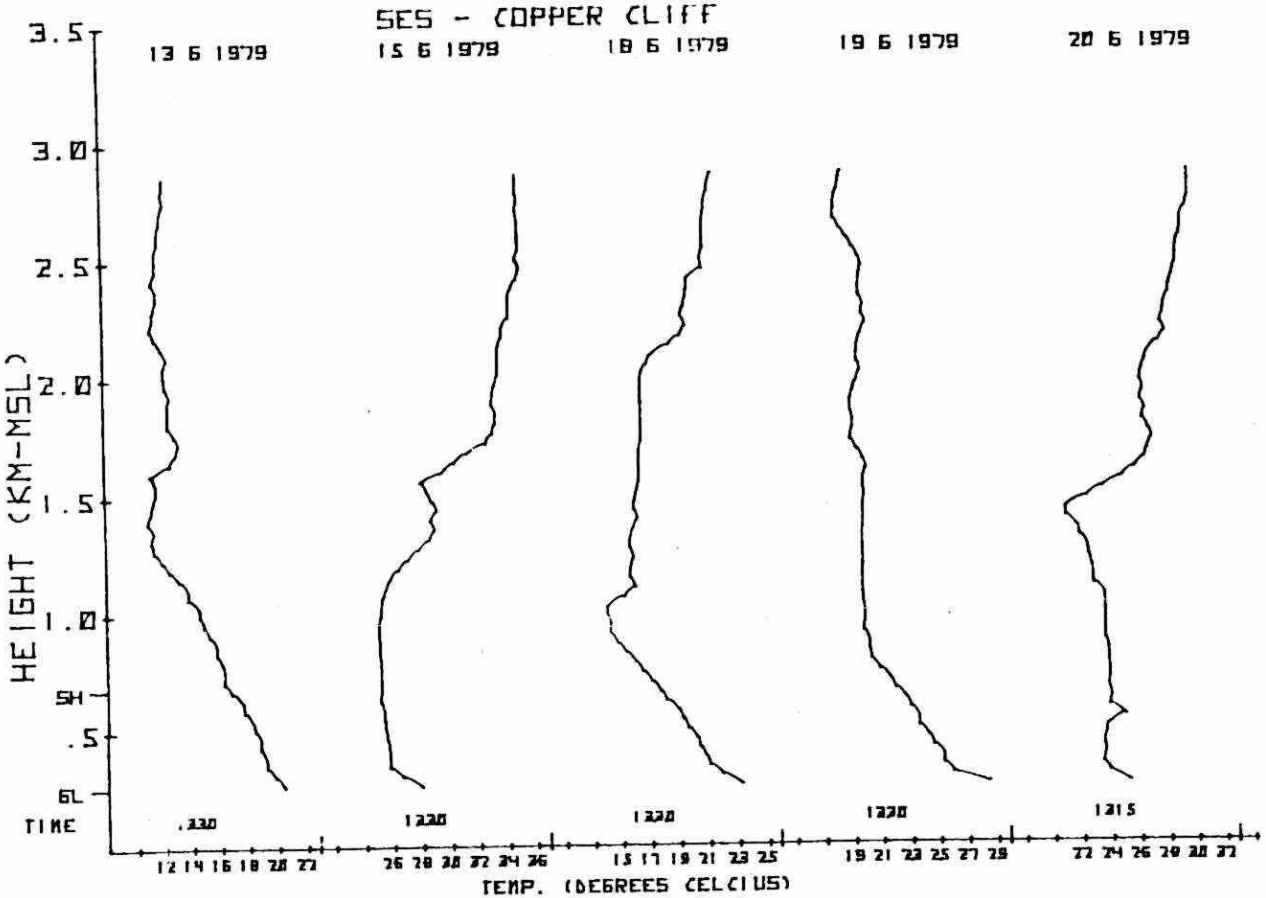
6 8 10 12 14 16
TEMP. (DEGREES CELCIUS)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2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1330
1330
1330
1330
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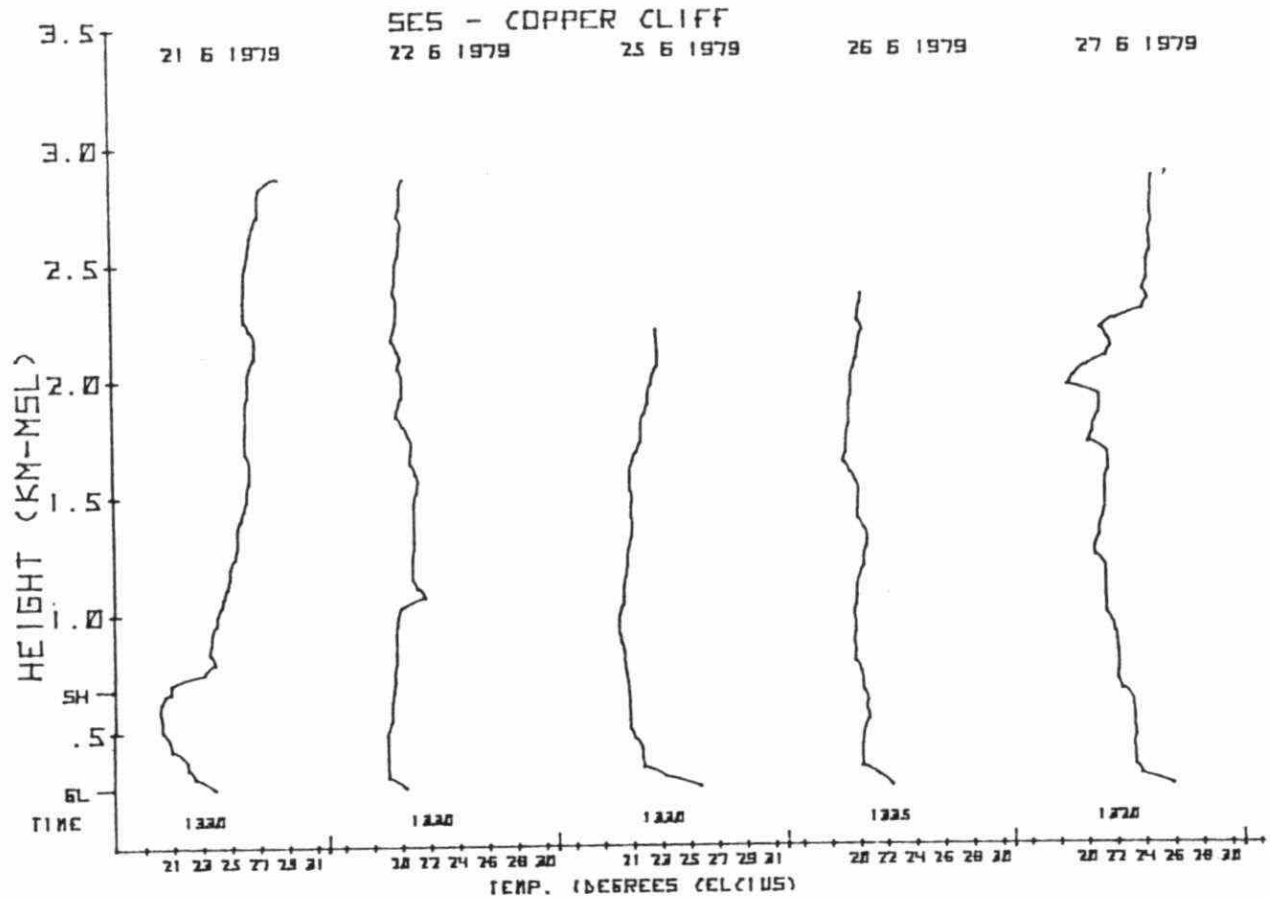
22 24 26 28 30 32
TEMP. (DEGREES CELCIUS)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26 6 1979
27 6 1979
HEIGHT (KM-MSL)
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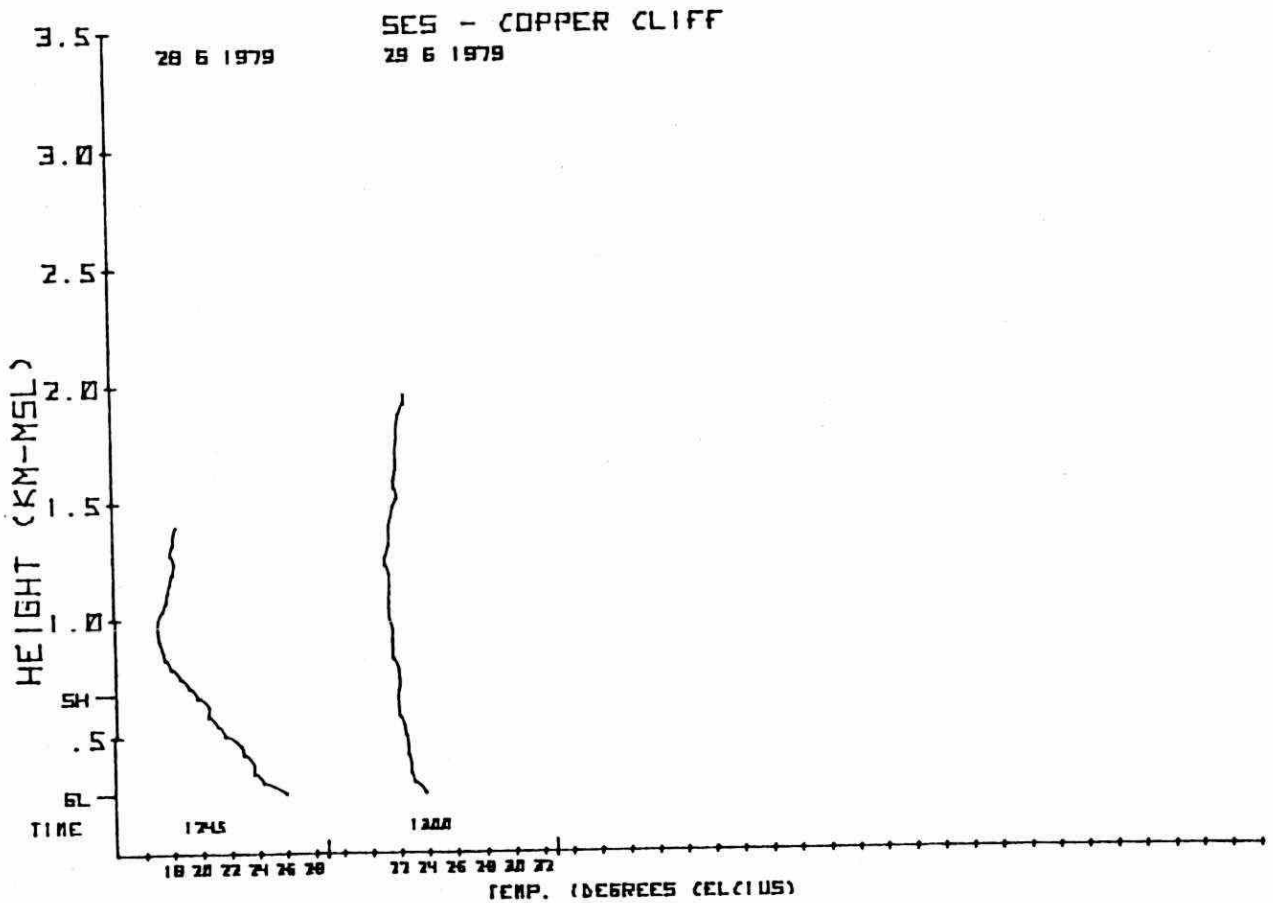
2.0
1.5
1.0
SH
.5
GL
TIME
TEMP. (DEGREES CELCIUS)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2.5
2.0
1.5
1.0
SH
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TIME
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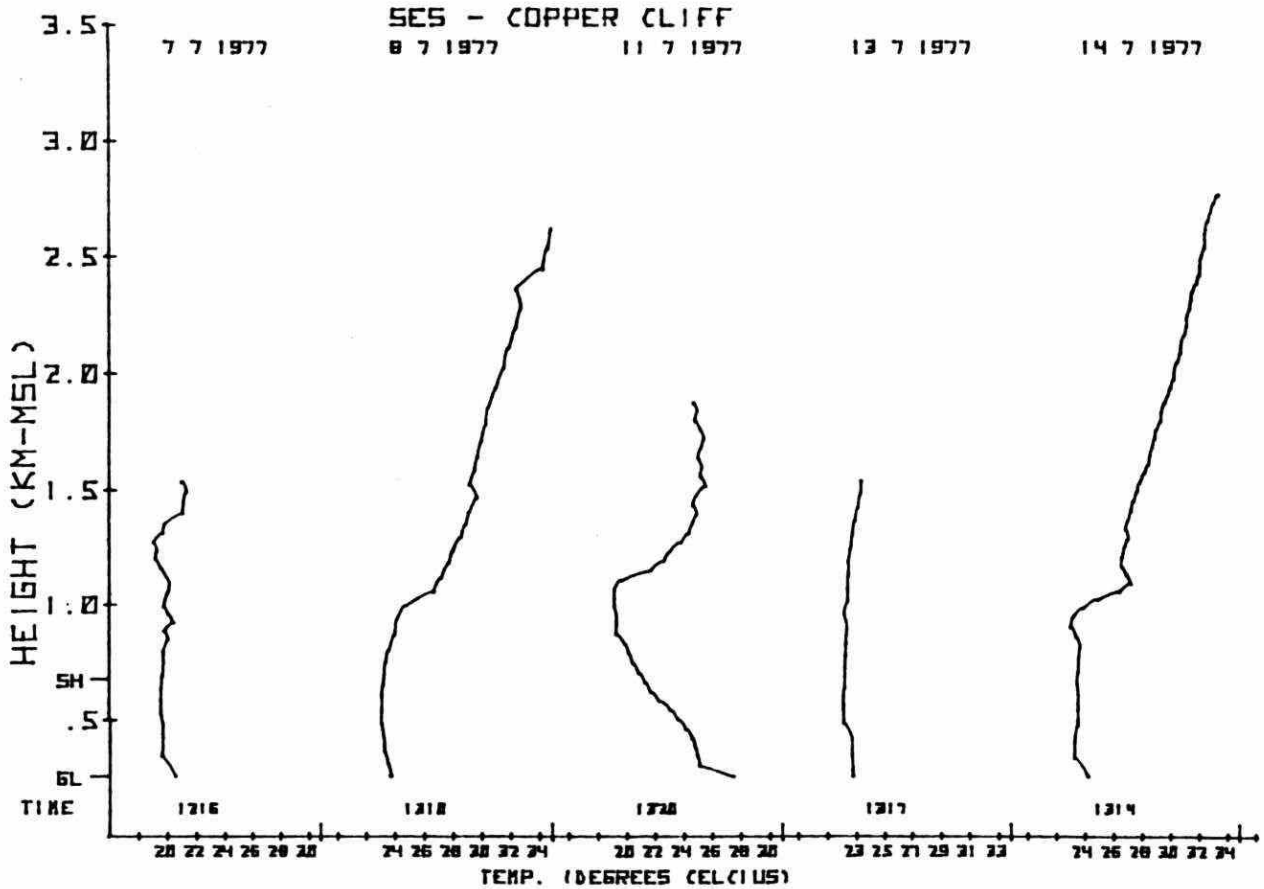
1300
18 20 22 24 26 28
22 24 26 28 30 32
TEMP. (DEGREES CELCIUS)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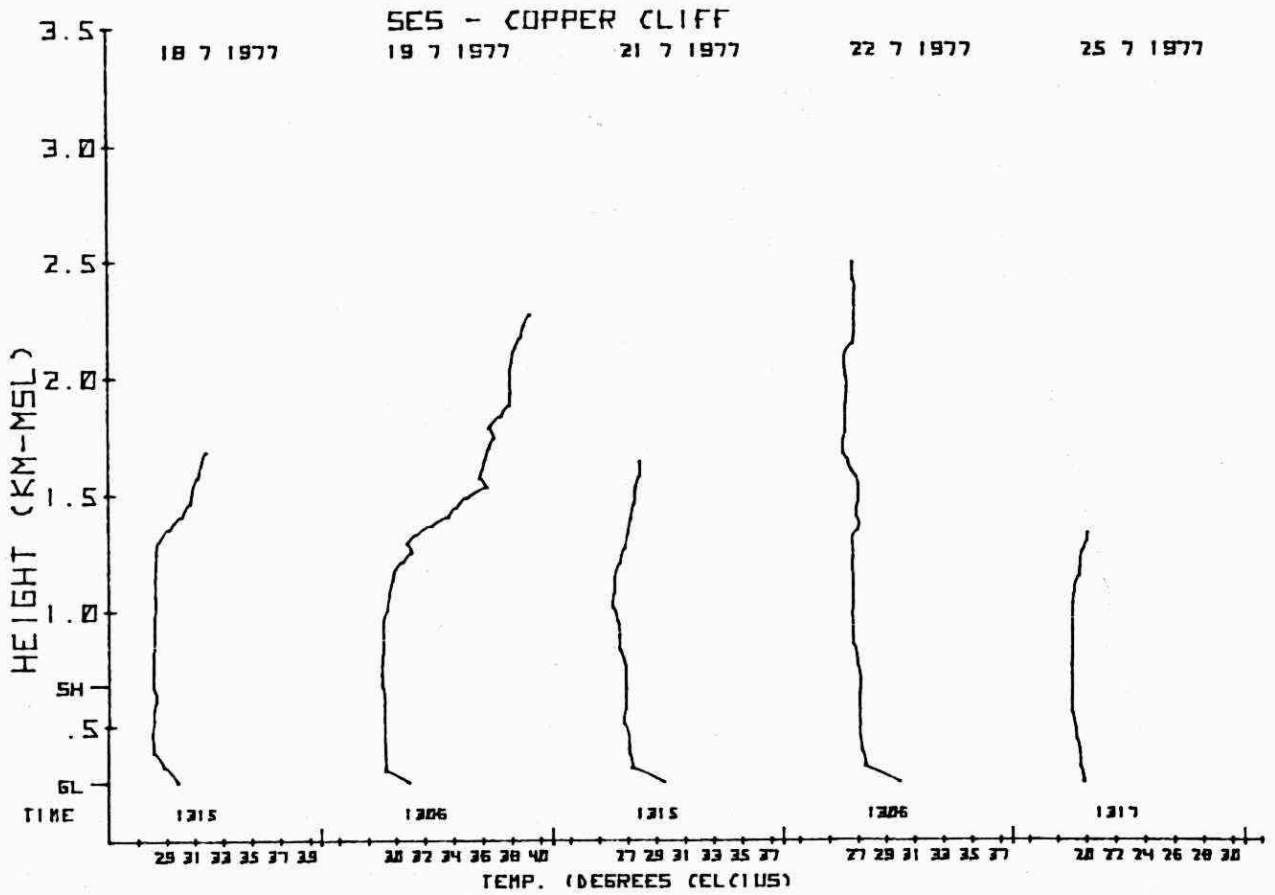
13 7 1977
14 7 1977
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1216
1318
1328
1317
1314
20 22 24 26 28 30
24 26 28 30 32 34
20 22 24 26 28 30
23 25 27 29 31 33
24 26 28 30 32 34
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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21 7 1977
22 7 1977
25 7 1977
HEIGHT (KM-MSL)
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3.0
2.5
2.0
1.5
1.0
SH
.5
GL
TIME
1315
1306
1315
1306
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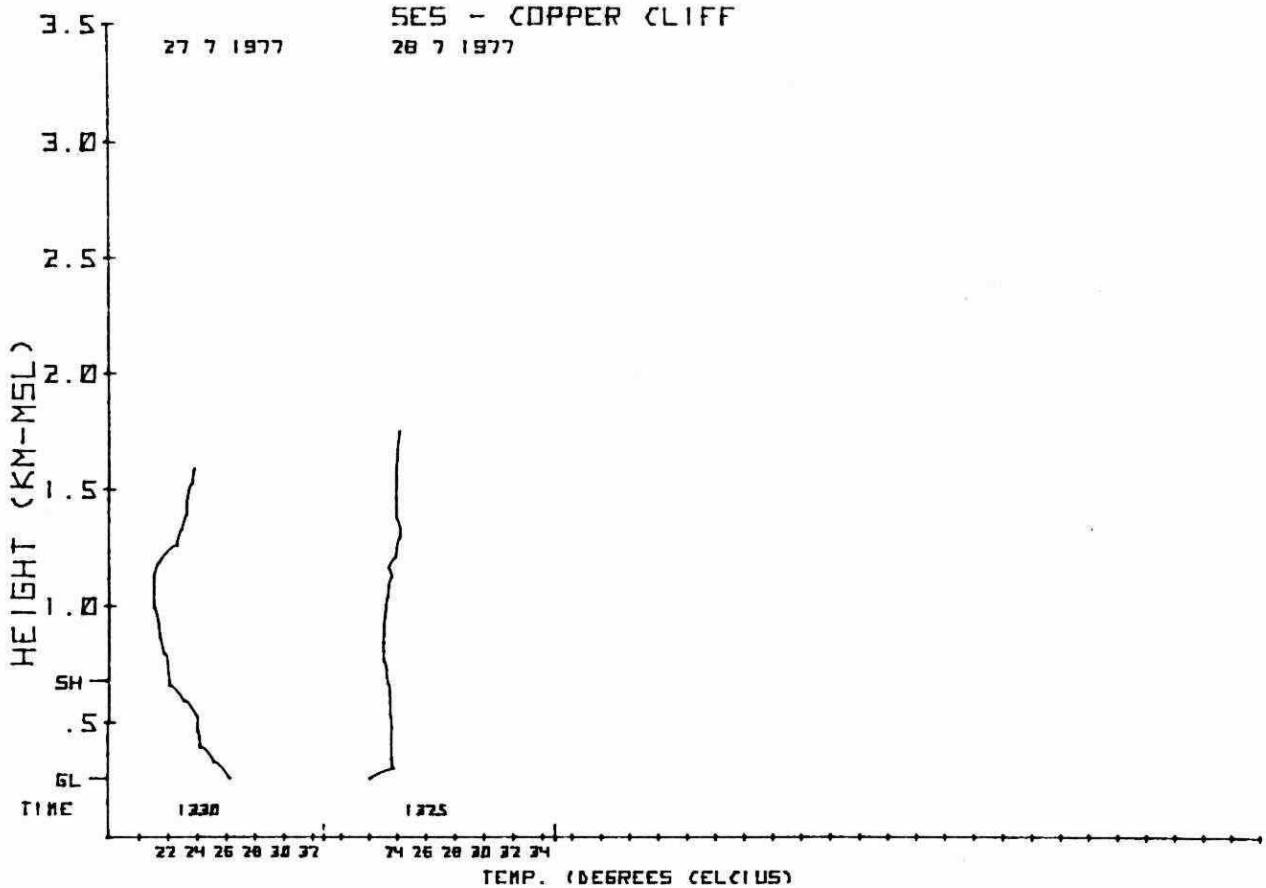
27 29 31 33 35 37
27 29 31 33 35 37
28 22 24 26 28 30
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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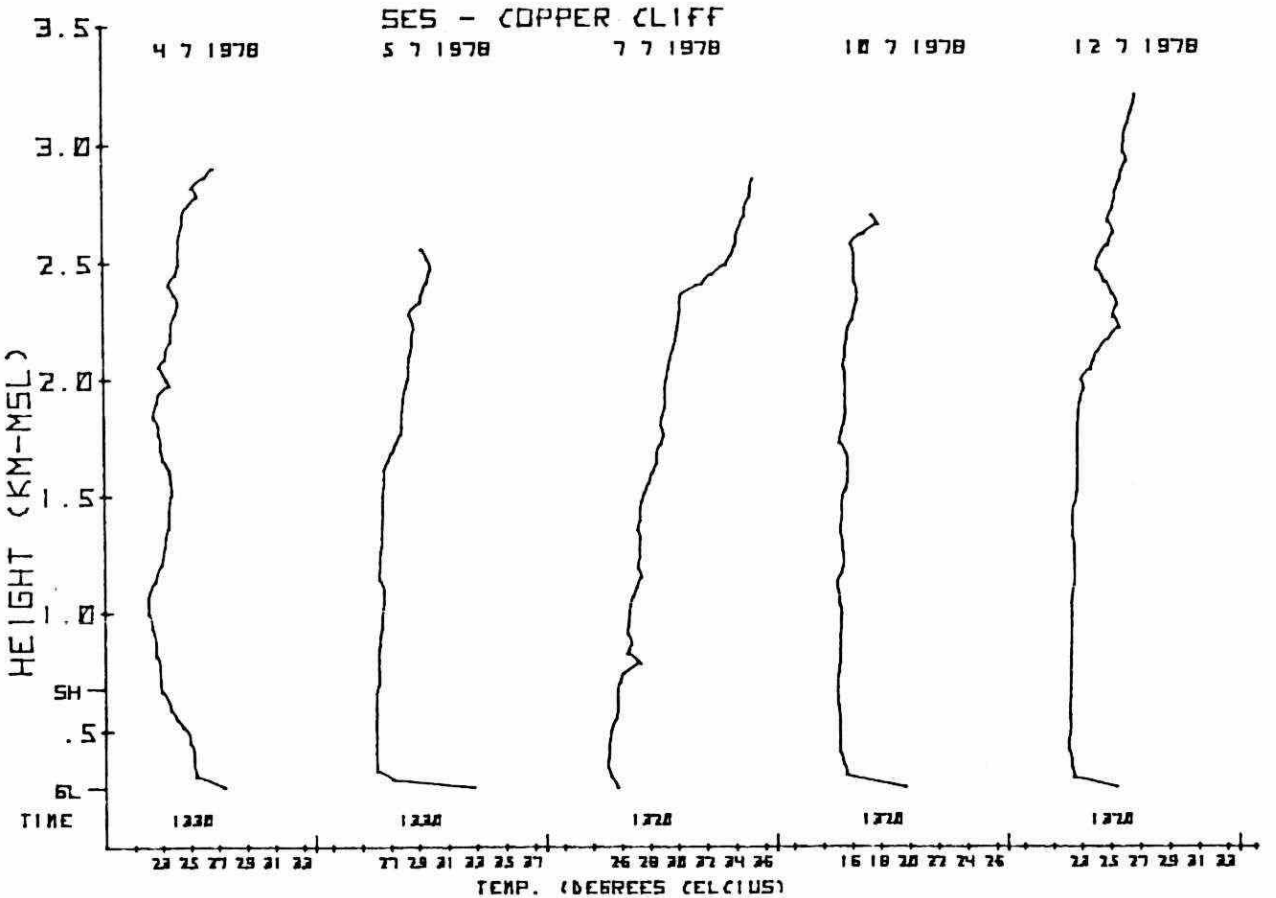
28 7 1977
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1330
1325
22 24 26 28 30 32
24 26 28 30 32 34
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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5 7 1978
7 7 1978
10 7 1978
12 7 1978
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1.5
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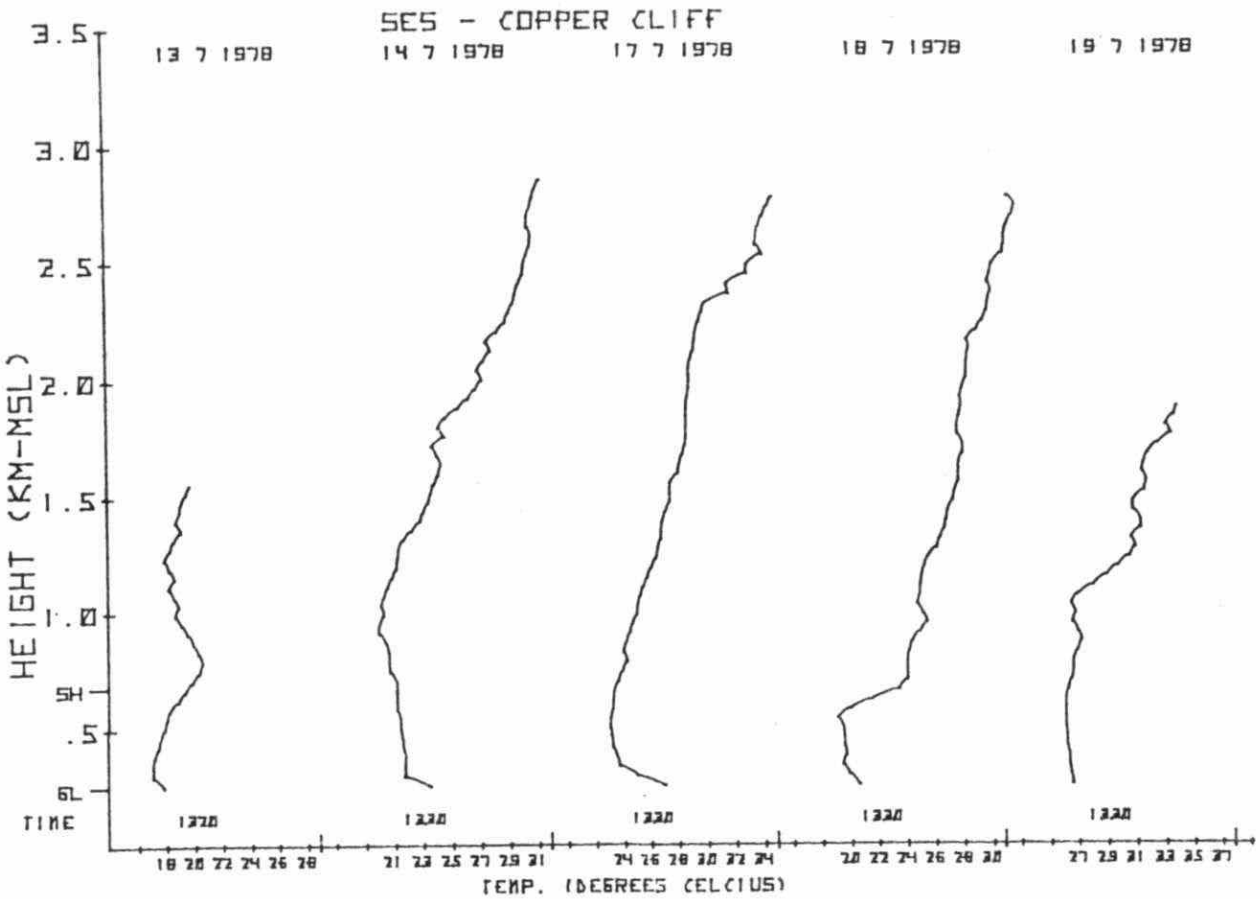
SH
.5
GL
HEIGHT (KM-MSL)
TIME
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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14 7 1978
17 7 1978
18 7 1978
19 7 1978
HEIGHT (KM-MSL)
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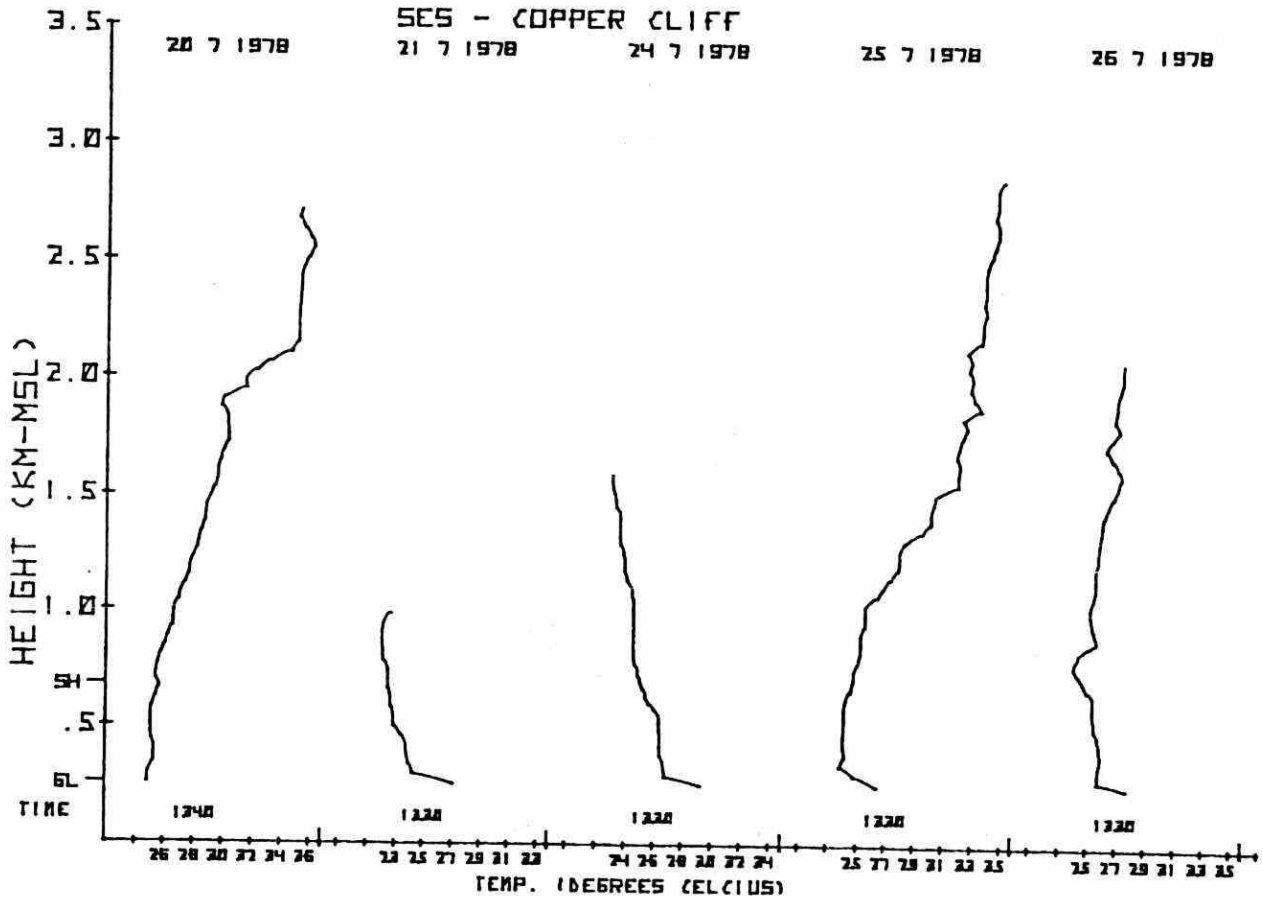
2.5
2.0
1.5
1.0
SH
.5
GL
TIME
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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21 7 1978
24 7 1978
25 7 1978
26 7 1978
HEIGHT (KM-MSL)
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3.0
2.5
2.0
1.5
1.0
SH
.5
GL
TIME
1340
1330
1330
1330
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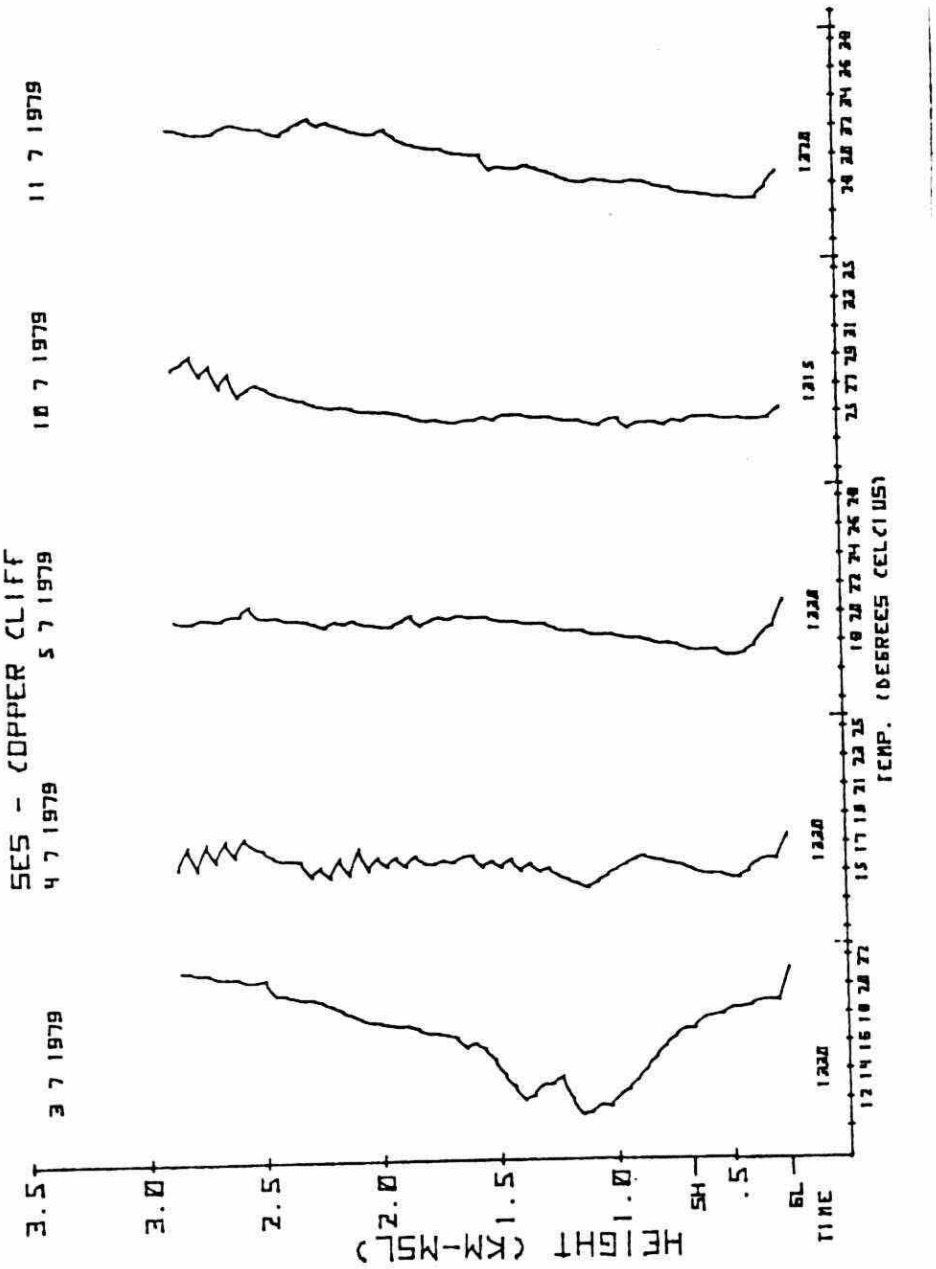
25 27 29 31 33 35
TEMP. (DEGREES CELCIUS)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10 7 1979
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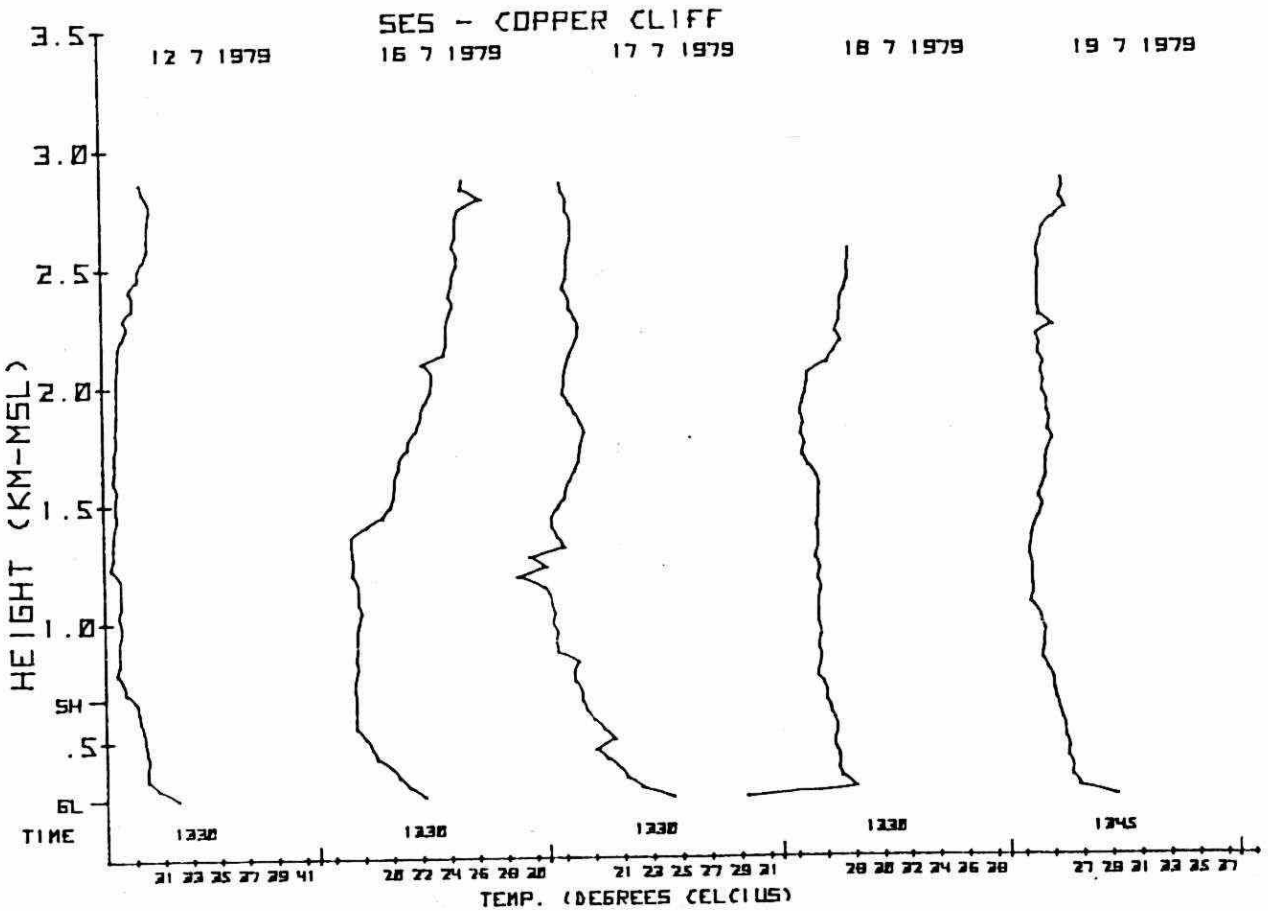
HEIGHT (KM-MSL)
TIME
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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18 7 1979
19 7 1979
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2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1330
1330
1330
1330
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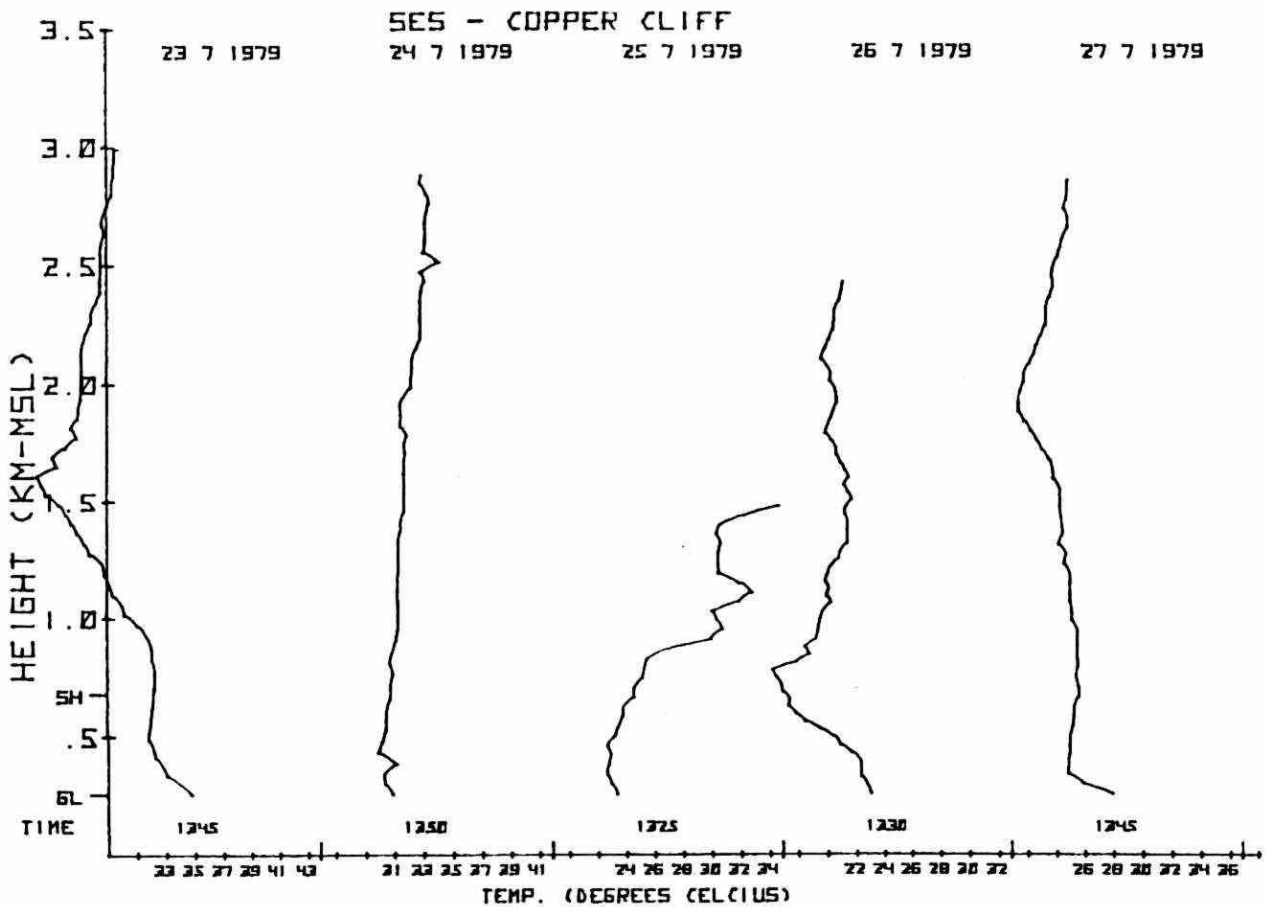
27 29 21 23 25 27
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1345
1350
1325
1330
1345
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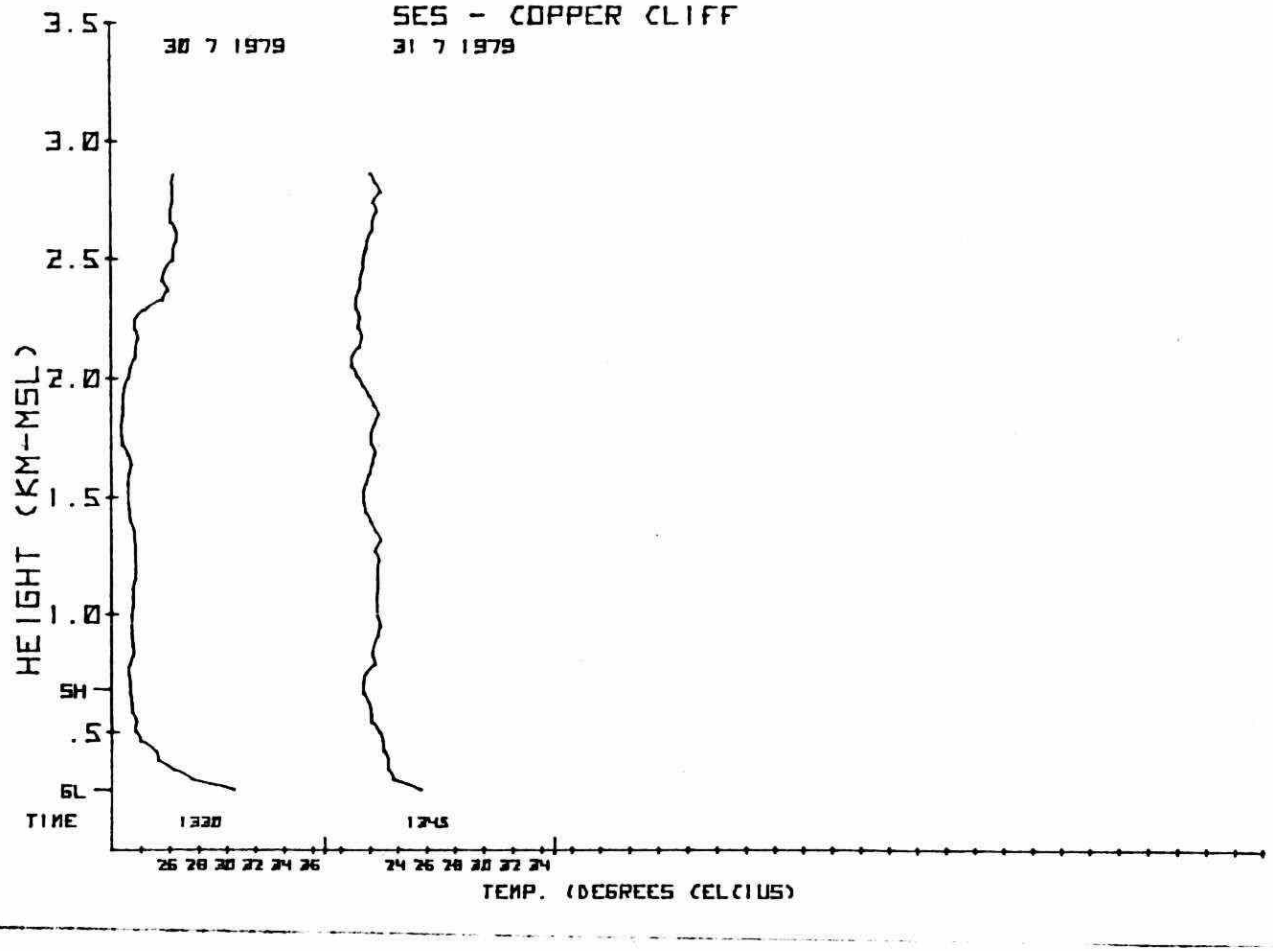
26 28 30 32 34 36
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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1.5
1.0
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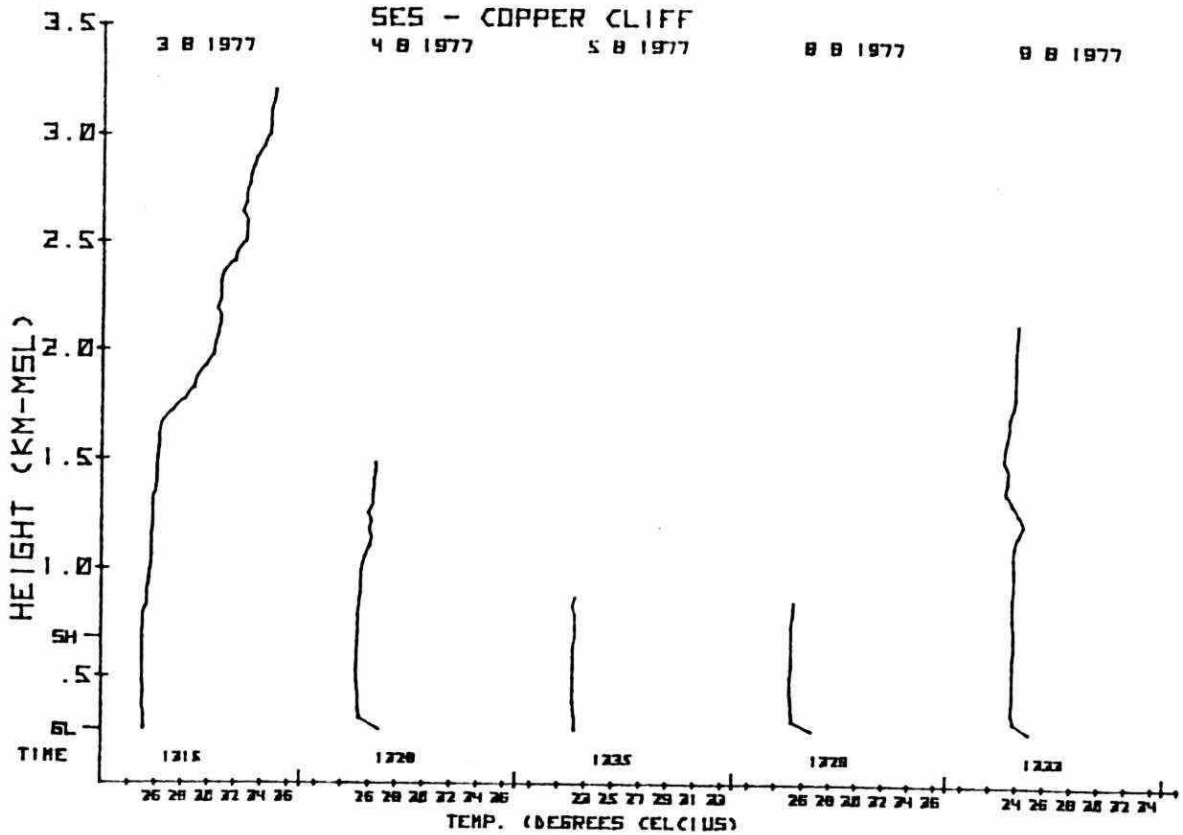
HEIGHT (KM-MSL)
TIME
1330
1245
26 28 30 32 24 26
24 26 28 30 32 24
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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5 8 1977
8 8 1977
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HEIGHT (KM-MSL)
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2.5
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SH
.5
GL
TIME
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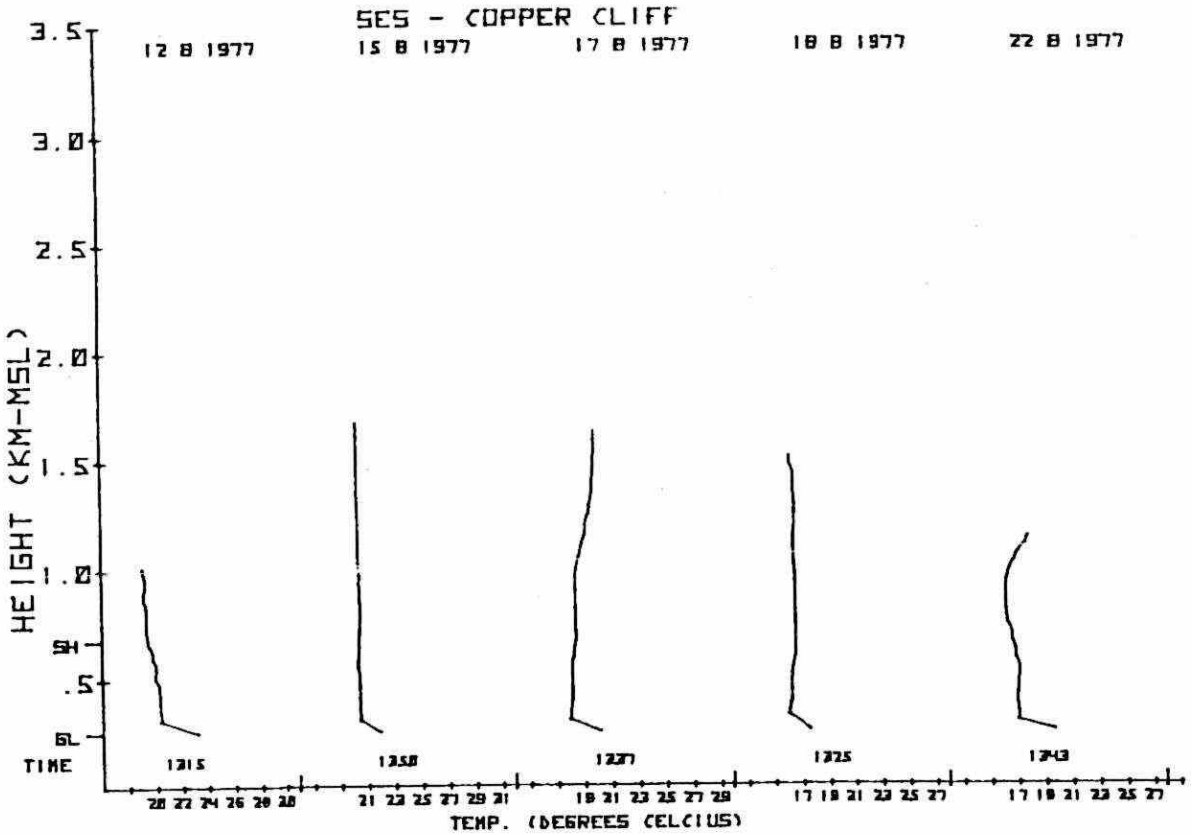
1220
1235
1220
1223
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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17 8 1977
18 8 1977
22 8 1977
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2.5
2.0
1.5
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GL
HEIGHT (KM-MSL)
TIME
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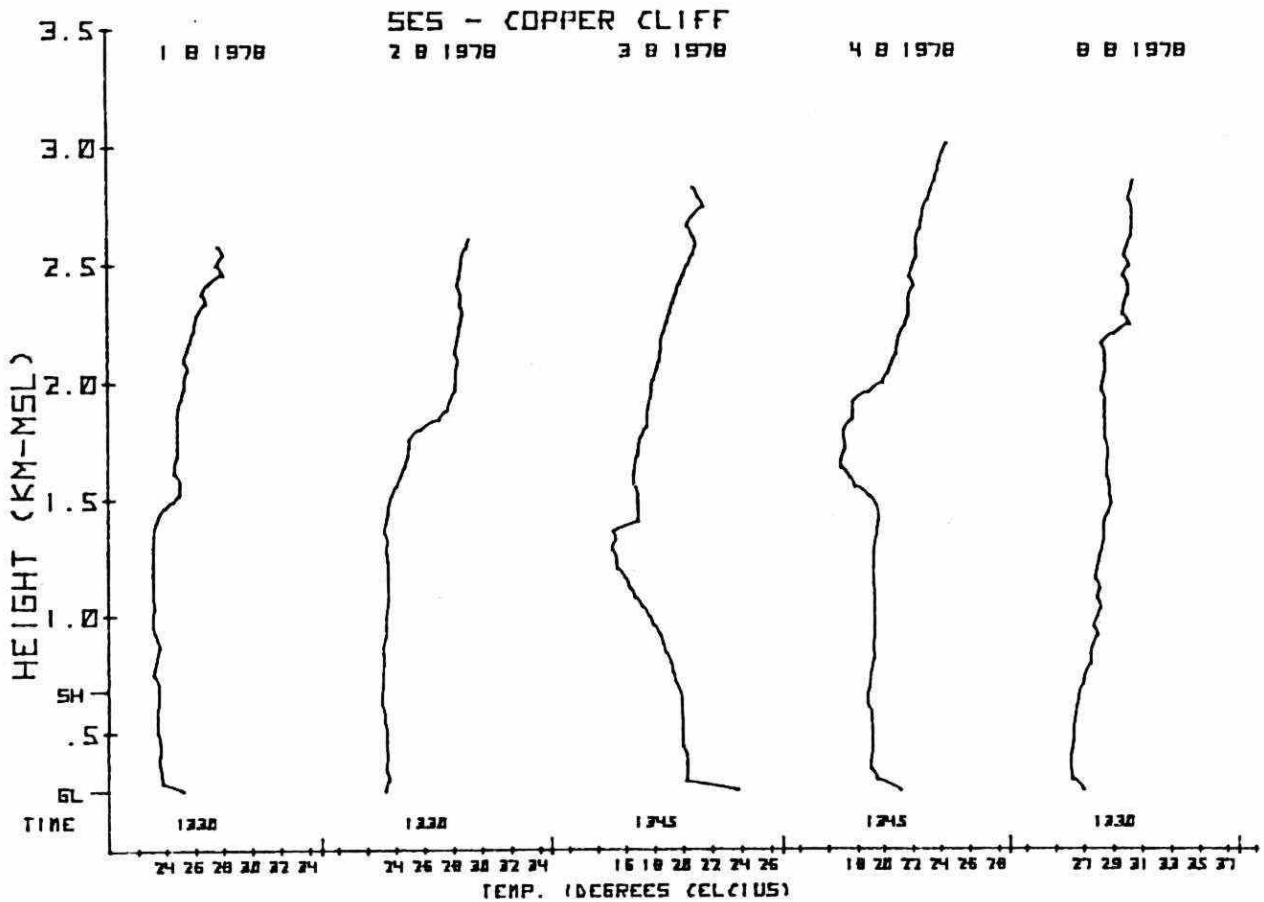
1358
1237
1325
1343
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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3 8 1978
4 8 1978
8 8 1978
HEIGHT (KM-MSL)
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3.0
2.5
2.0
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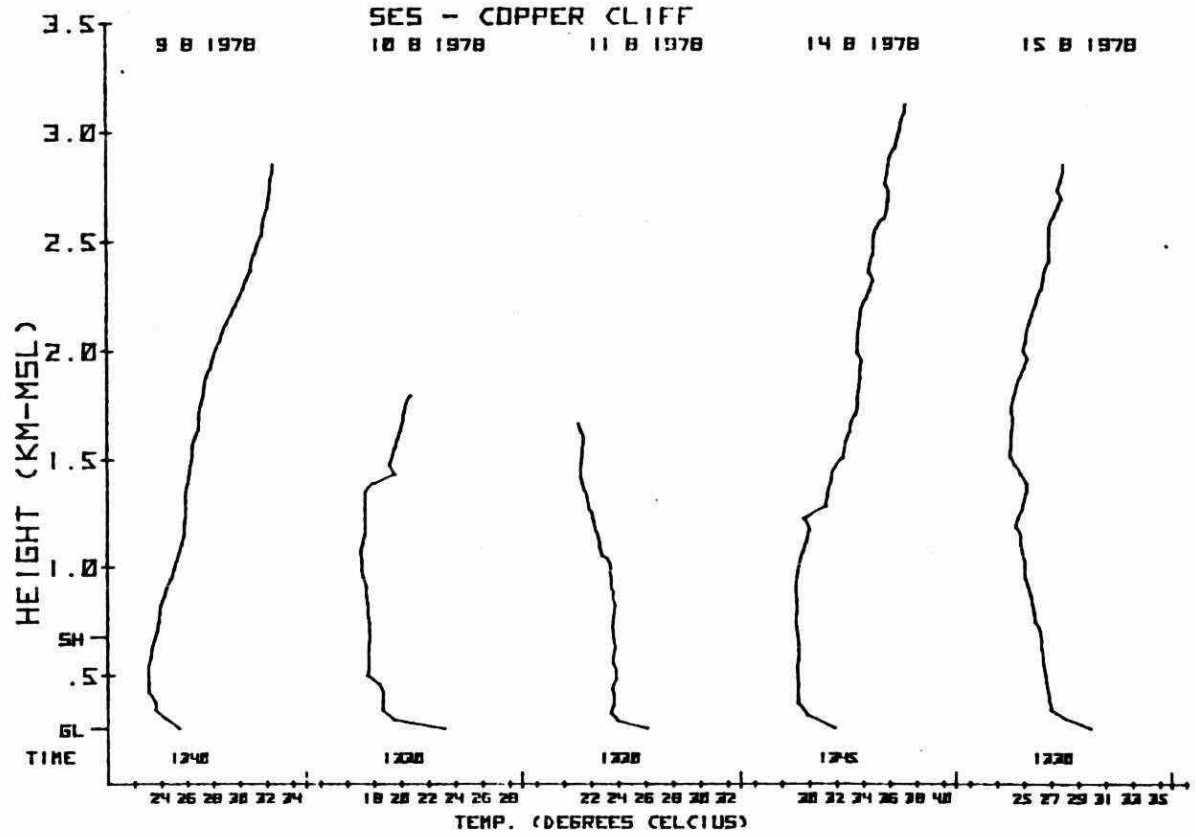
SH
.5
GL
TIME
1330
1330
1345
1345
1330
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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14 8 1978
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HEIGHT (KM-MSL)
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3.0
2.5
2.0
1.5
1.0
SH
.5
GL
TIME
1240
1230
1230
1245
1220
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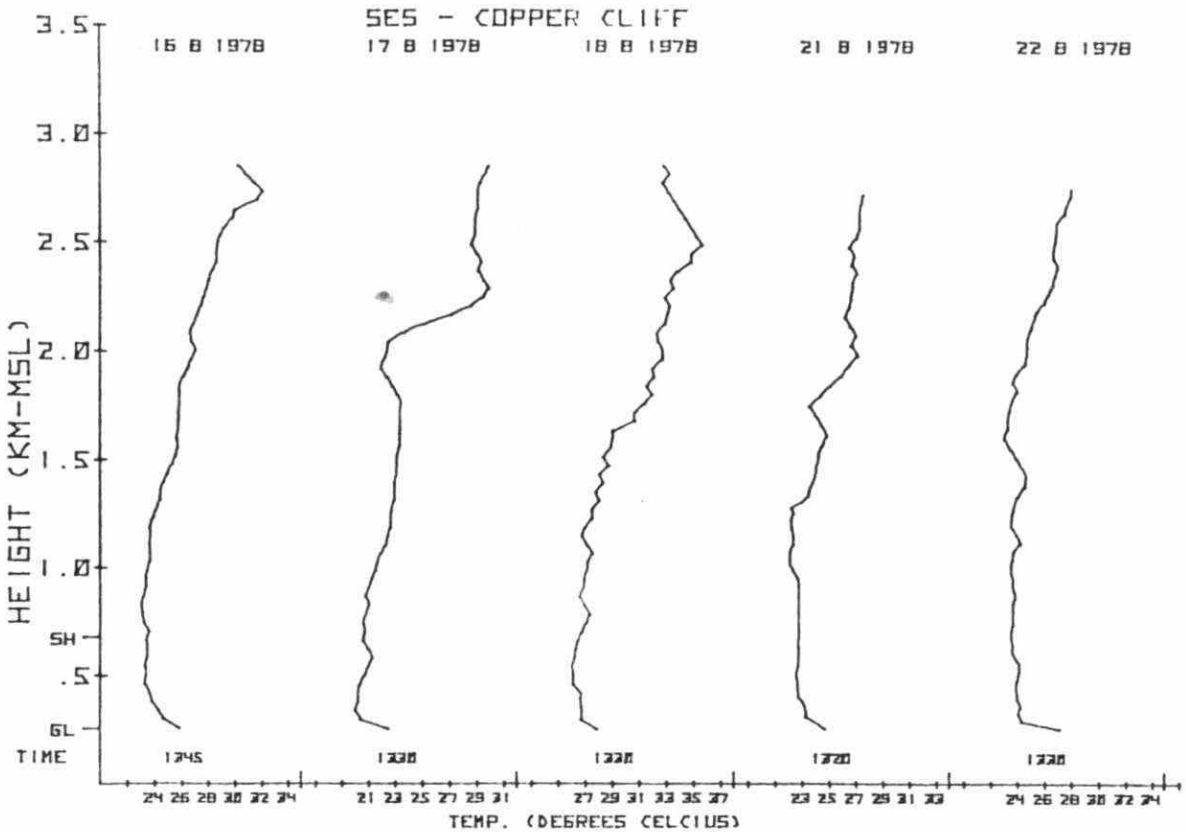
25 27 29 31 33 35
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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HEIGHT (KM-MSL)
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3.0
2.5
2.0
1.5
1.0
SH
.5
GL
TIME
1345
1330
1330
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24 26 28 30 32 34
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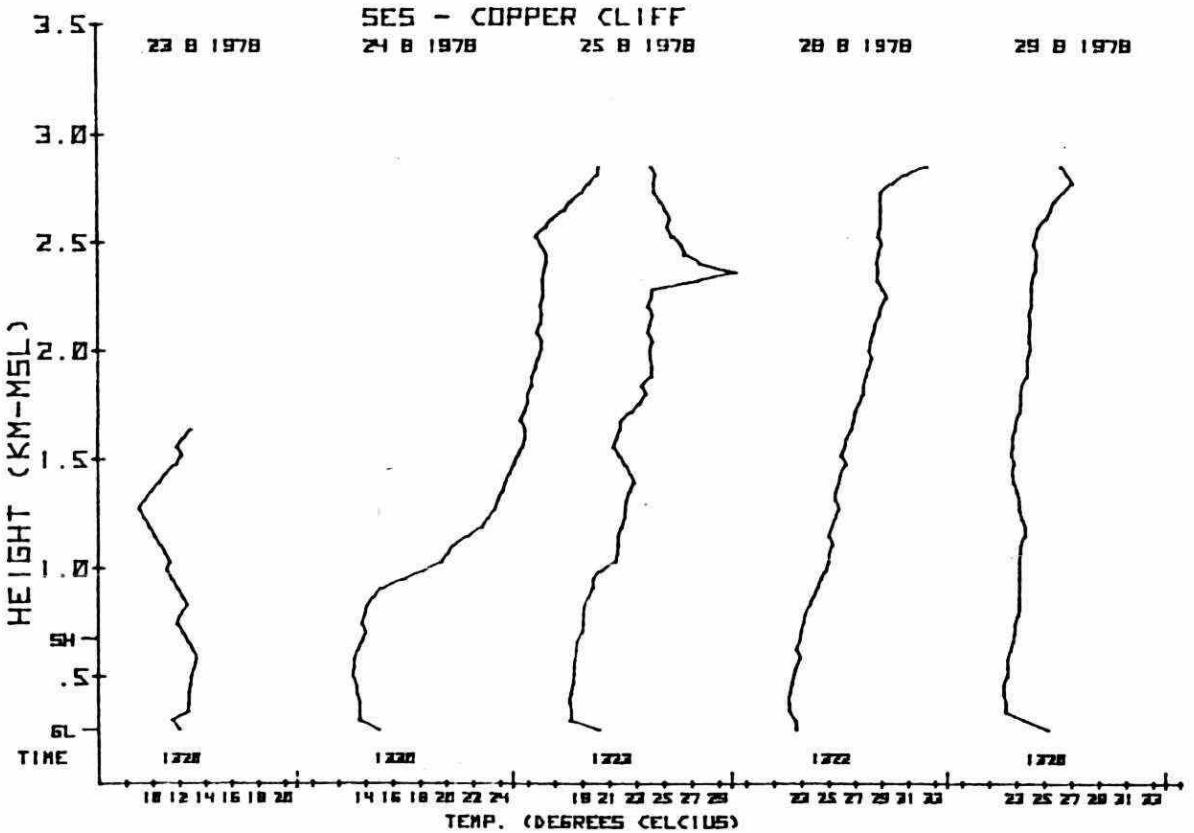
24 26 28 30 32 34
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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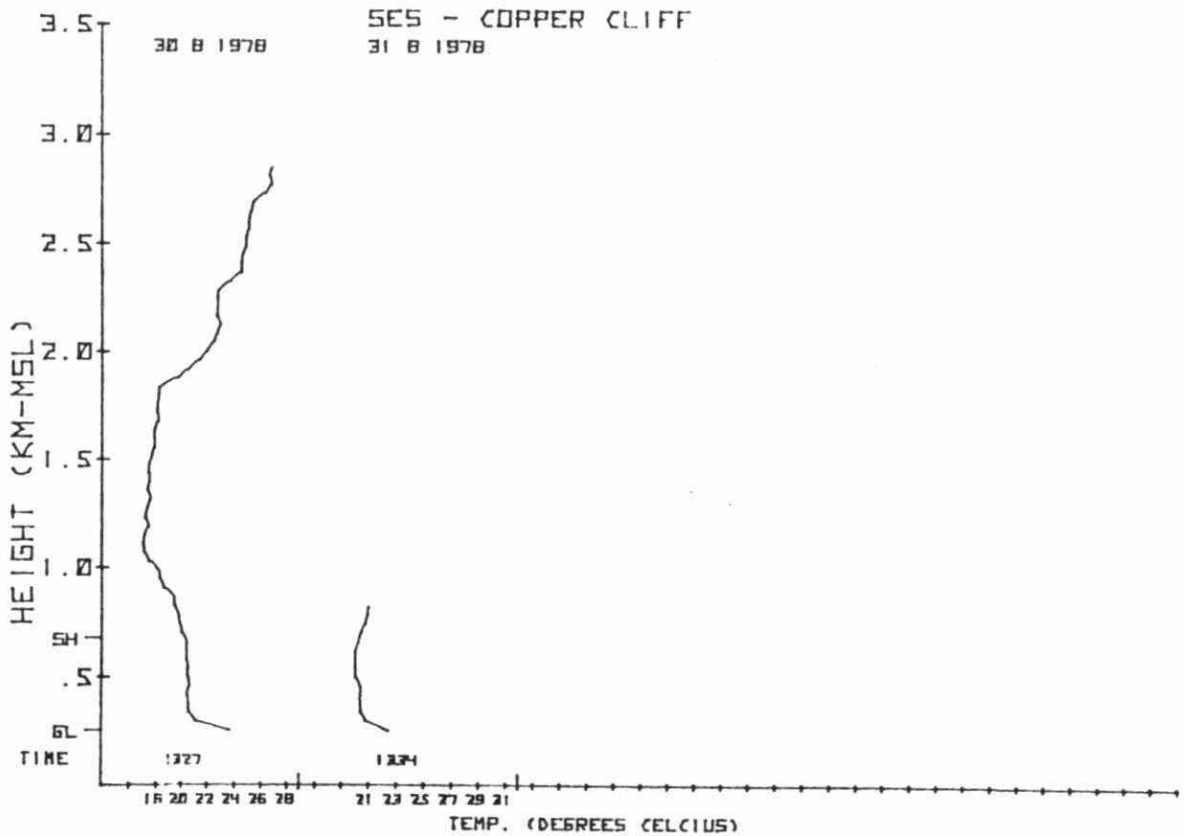
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1220
1230
1223
1222
1228
18 12 14 16 18 20
14 16 18 20 22 24
18 21 23 25 27 29
23 25 27 29 31 33
23 25 27 29 31 33
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
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31 8 1978
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2.5
2.0
1.5
1.0
SH
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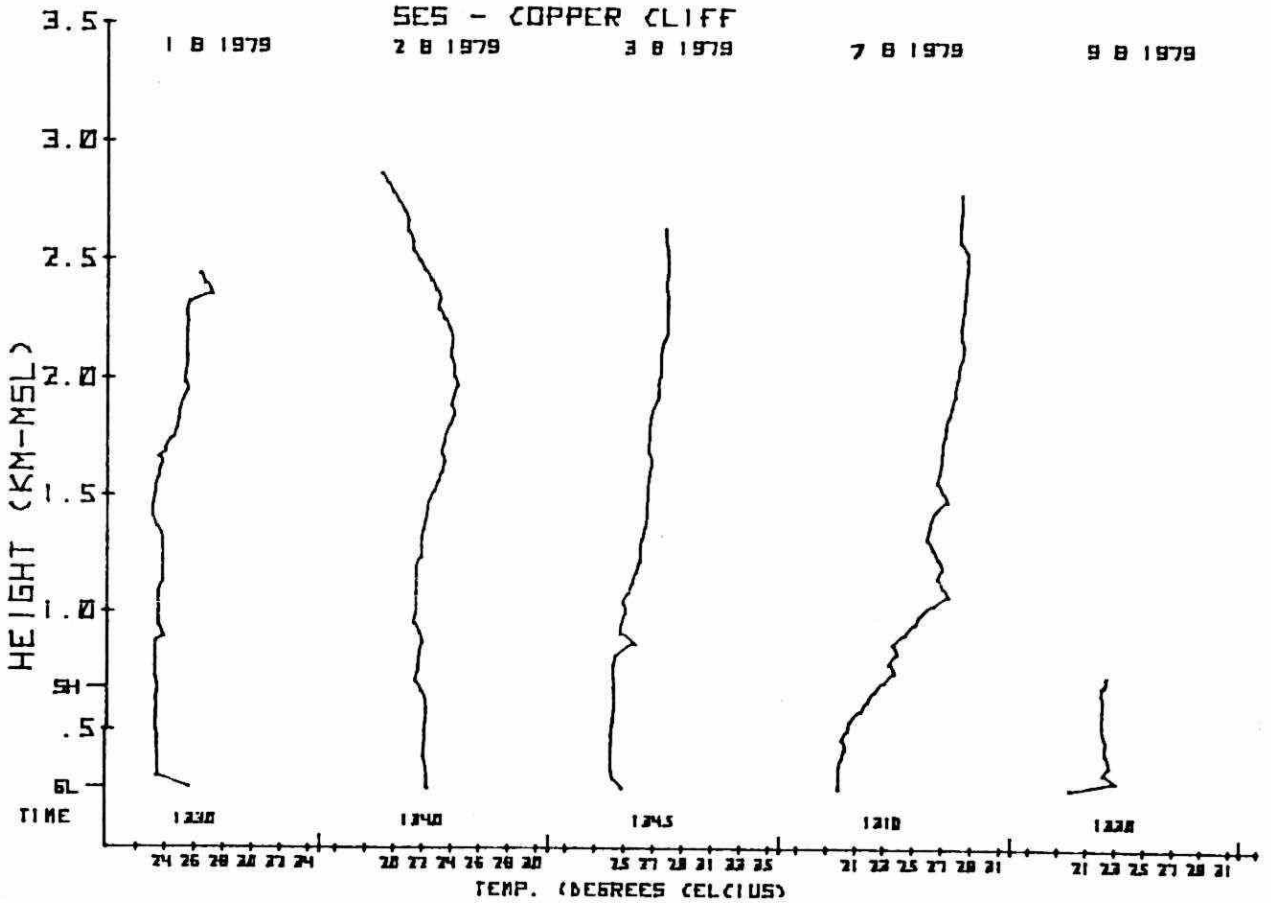
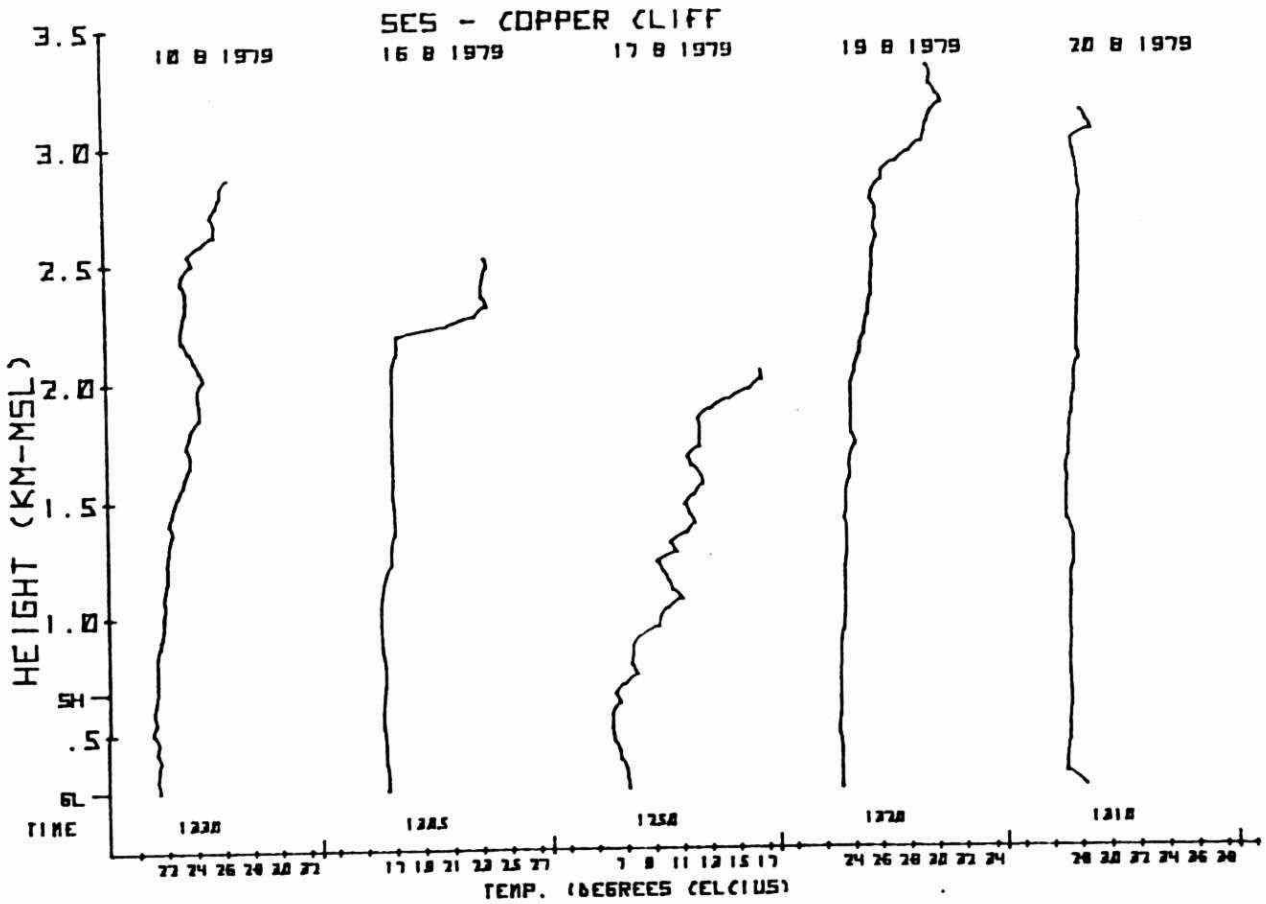
GL
HEIGHT (KM-MSL)
TIME
1327
1324
16 18 20 22 24 26 28
21 23 25 27 29 31
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
1 8 1979
2 8 1979
3 8 1979
7 8 1979
9 8 1979
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1330
1340
1345
1310
1330
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
16 8 1979
17 8 1979
19 8 1979
20 8 1979
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3.0
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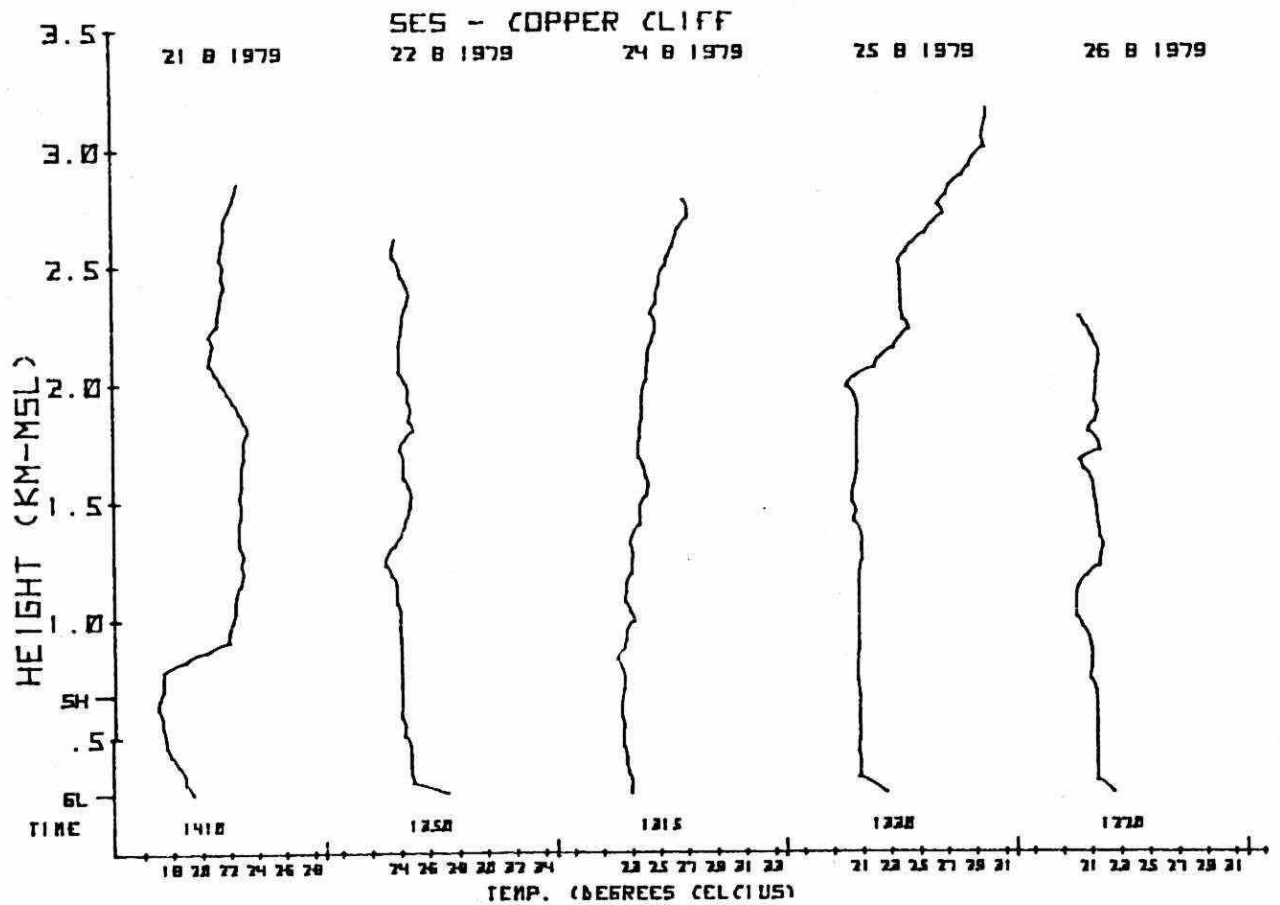
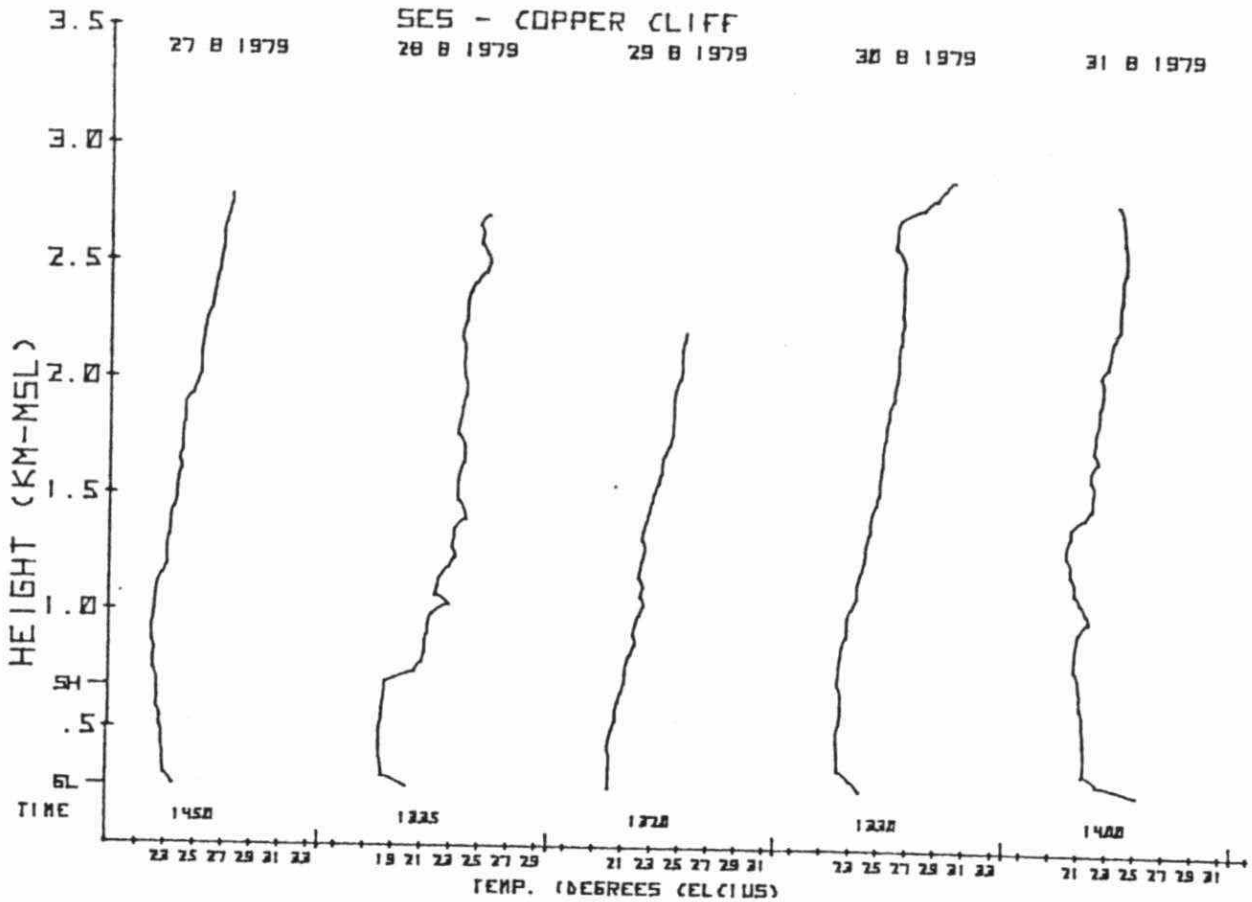
2.0
1.5
1.0
.5
HEIGHT (KM-MSL)
TIME
TEMP. (DEGREES CELCIUS)


SES - COPPER CLIFF
21 8 1979
22 8 1979
24 8 1979
25 8 1979
26 8 1979
HEIGHT (KM-MSL)
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
TIME
1410
1350
1315
1330
1230
TEMP. (DEGREES CELCIUS)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2.0
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GL
HEIGHT (KM-MSL)
TIME
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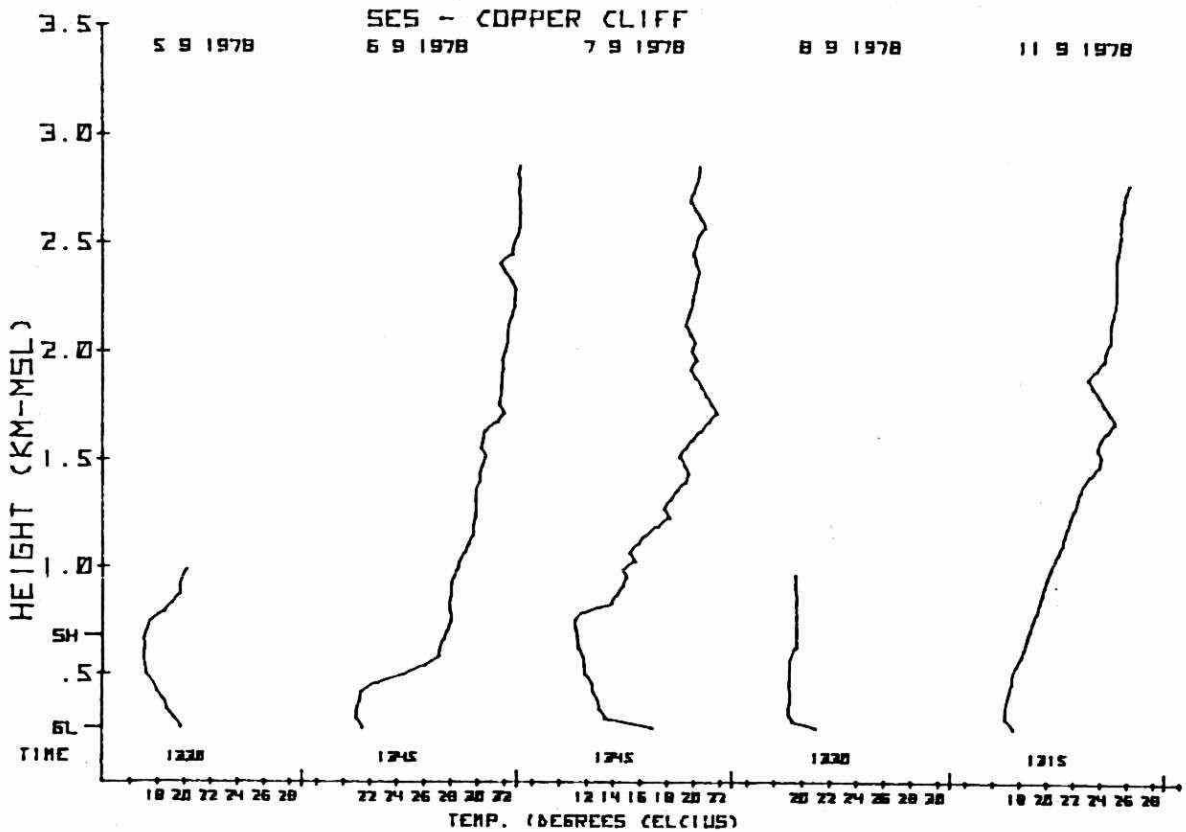
1328
1330
1400
TEMP. (DEGREES CELCIUS)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HEIGHT (KM-MSL)
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2.5
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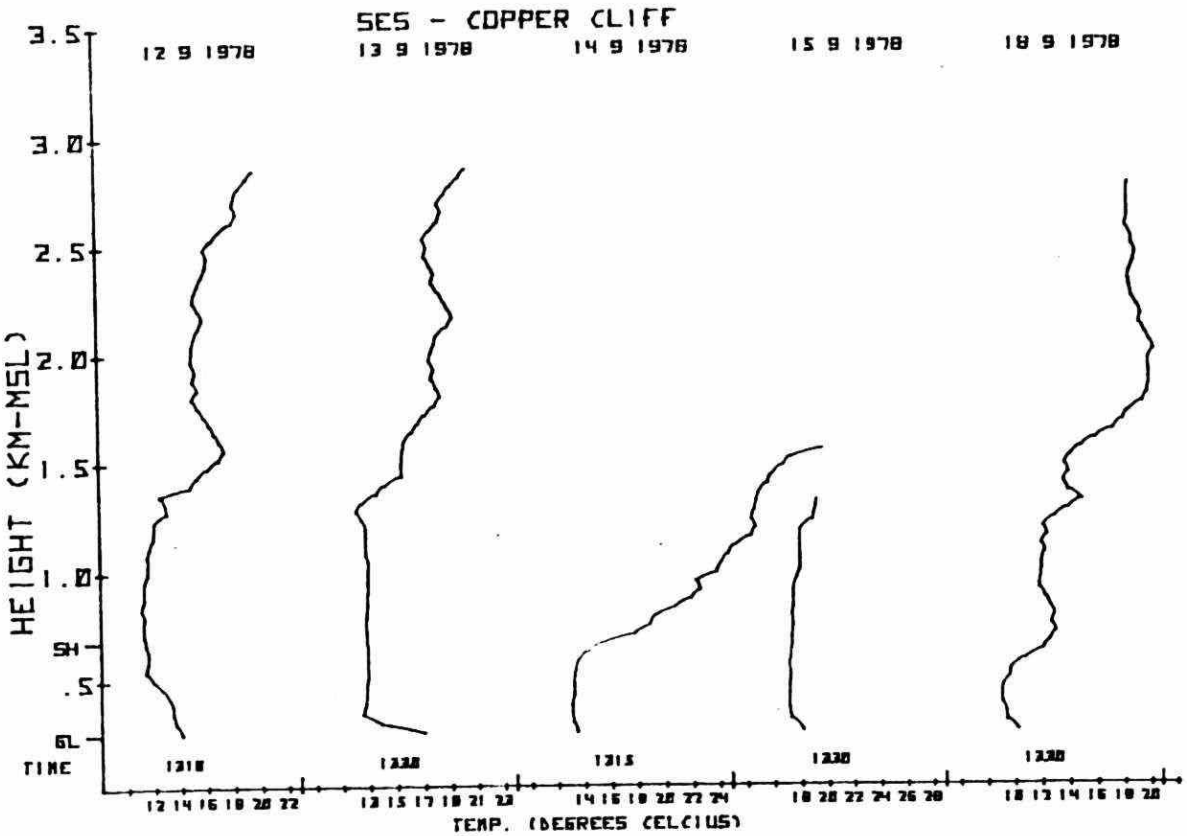
SH
.5
GL
TIME
1230
1245
1245
1230
1315
TEMP. (DEGREES CELCIUS)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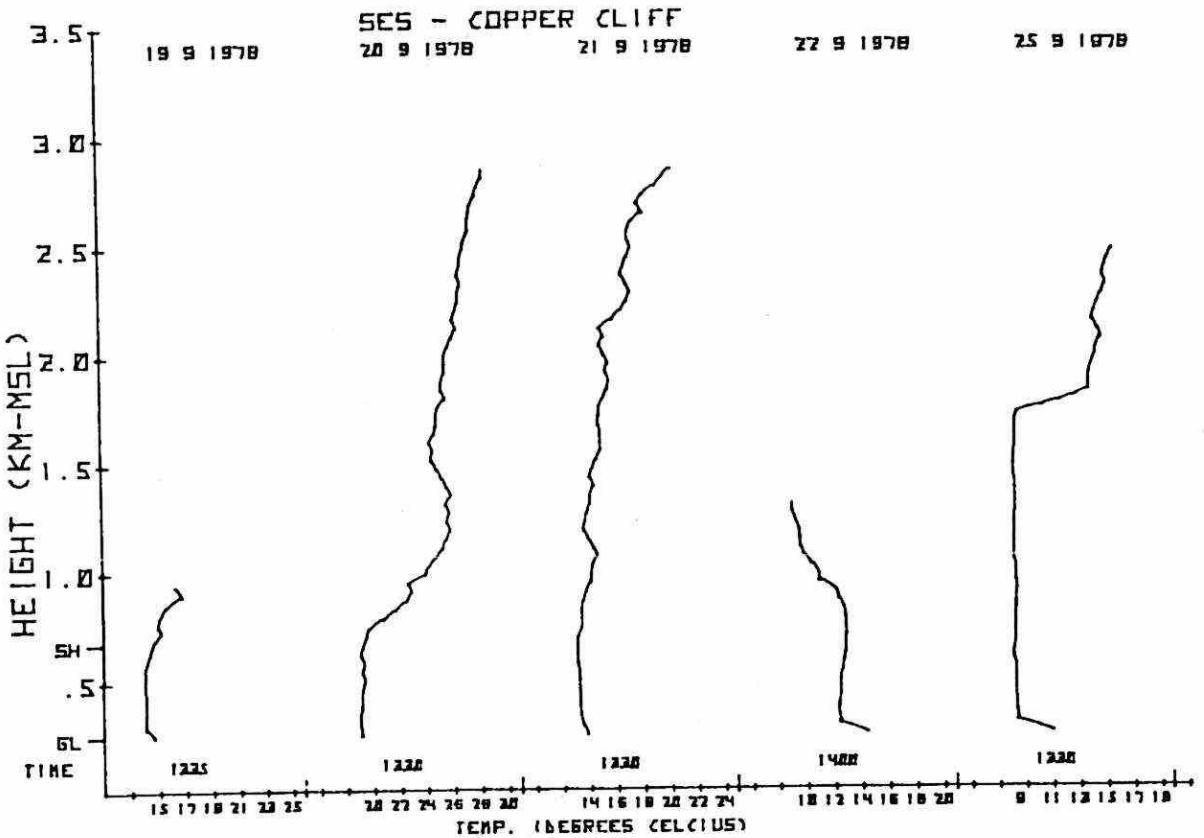
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1318
1338
1315
1330
1330
12 14 16 18 20 22
13 15 17 19 21 23
14 16 18 20 22 24
18 20 22 24 26 28
18 12 14 16 18 20
TEMP. (DEGREES CELCIUS)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22 9 1978
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HEIGHT (KM-MSL)
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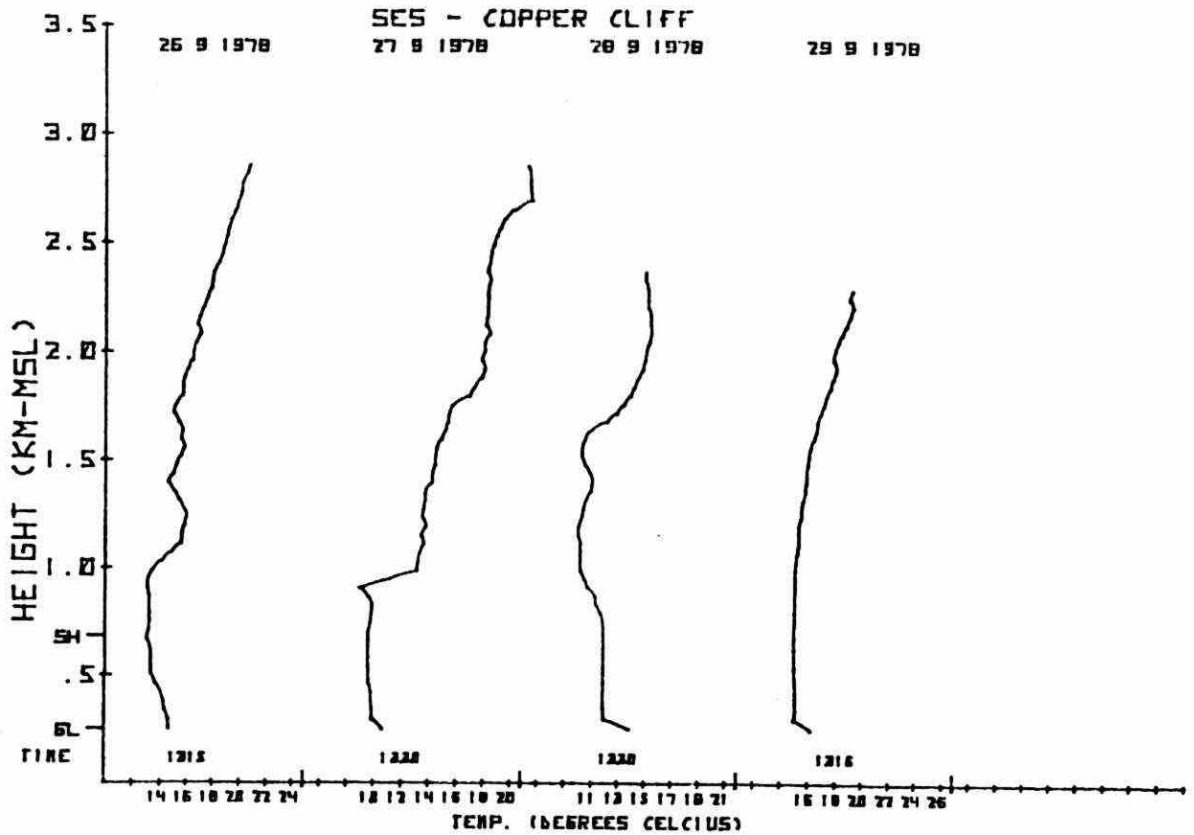
2.5
2.0
1.5
1.0
SH
.5
GL
TIME
TEMP. (DEGREES CELCIUS)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28 9 1978
29 9 1978
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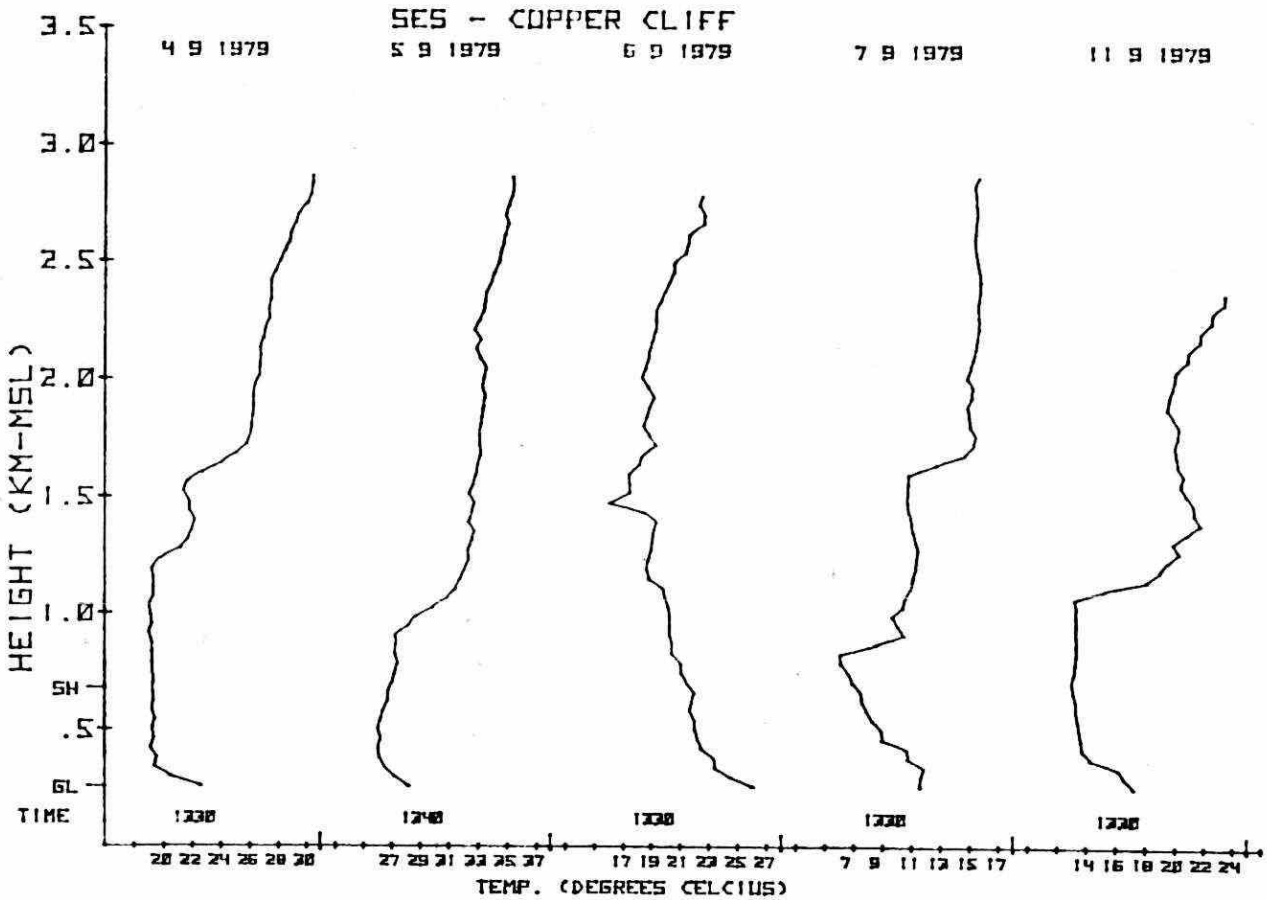
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1315
1330
1330
1316
14 16 18 20 22 24
12 12 14 16 18 20
11 13 15 17 19 21
16 18 20 22 24 26
TEMP. (DEGREES CELCIUS)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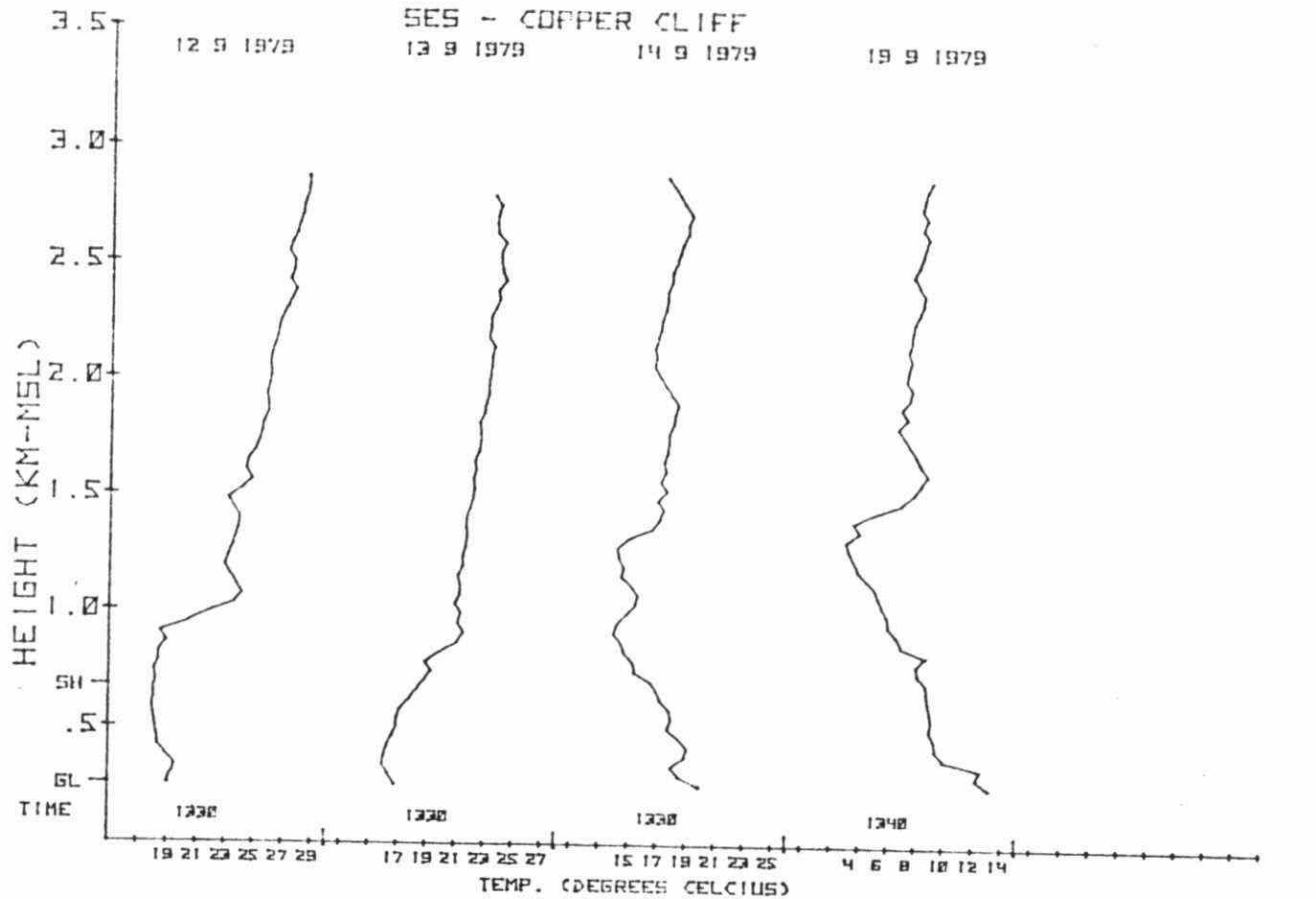
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1330
1240
1330
1330
1330
20 22 24 26 28 30
27 29 31 33 35 37
17 19 21 23 25 27
7 9 11 13 15 17
14 16 18 20 22 24
TEMP. (DEGREES CELCIUS)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13 9 1979
14 9 1979
19 9 1979
3.5
3.0
2.5
2.0
1.5
1.0
SH
.5
GL
HEIGHT (KM-MSL)
TIME
1330
1330
1330
1340
19 21 23 25 27 29
17 19 21 23 25 27
15 17 19 21 23 25
4 6 8 10 12 14
TEMP. (DEGREES CELCIUS)

Appendix 5

Solar Flux Analyses

Section A5(a): All days

Section A5(b): Convective Days Only

Section A5(a)

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month: JANUARY 1979

Hour	Solar Flux (Watts/Sq.M.) Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	0	0	0	0	31
4- 5	0	0	0	0	31
5- 6	0	0	0	0	31
6- 7	0	0	0	0	31
7- 8	0	0	0	0	31
8- 9	74	0	19	20	28
9-10	213	0	99	56	28
10-11	344	74	187	76	28
11-12	418	74	258	96	28
12-13	492	127	303	111	28
13-14	508	82	284	118	28
14-15	463	57	228	106	28
15-16	270	16	125	65	28
16-17	98	0	34	26	28
17-18	12	0	1	3	28
18-19	0	0	0	0	31
19-20	0	0	0	0	31
20-21	0	0	0	0	31
21-22	0	0	0	0	31
22-23	0	0	0	0	31
23-24	0	0	0	0	31

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month: FEBRUARY 1979

Hour	Solar Flux (Watts/Sq.M.) Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	0	0	0	0	28
4- 5	0	0	0	0	28
5- 6	0	0	0	0	28
6- 7	0	0	0	0	28
7- 8	25	0	5	9	25
8- 9	188	16	77	53	25
9-10	369	57	190	97	25
10-11	524	49	297	133	25
11-12	606	66	373	153	25
12-13	631	49	402	166	25
13-14	614	57	400	154	25
14-15	533	74	349	130	27
15-16	492	41	275	121	28
16-17	287	25	153	74	28
17-18	90	8	33	21	28
18-19	0	0	0	0	28
19-20	0	0	0	0	28
20-21	0	0	0	0	28
21-22	0	0	0	0	28
22-23	0	0	0	0	28
23-24	0	0	0	0	28

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month: MARCH 1979

Hour	Solar Flux (Watts/Sq.M.) Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	0	0	0	0	31
4- 5	0	0	0	0	31
5- 6	0	0	0	0	31
6- 7	57	0	2	11	30
7- 8	254	0	54	65	30
8- 9	467	0	140	113	30
9-10	606	33	239	158	30
10-11	729	57	347	203	30
11-12	803	57	449	230	30
12-13	860	41	518	241	30
13-14	803	66	511	231	30
14-15	721	57	437	213	30
15-16	598	41	325	175	30
16-17	442	8	205	124	30
17-18	279	0	80	69	30
18-19	115	0	8	24	30
19-20	0	0	0	0	31
20-21	0	0	0	0	31
21-22	0	0	0	0	31
22-23	0	0	0	0	31
23-24	0	0	0	0	31

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month: APRIL 1979

Hour	Solar Flux (Watts/Sq.M.) Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	0	0	0	0	30
4- 5	0	0	0	0	30
5- 6	0	0	0	0	30
6- 7	156	0	73	47	20
7- 8	344	16	184	111	20
8- 9	533	25	319	183	20
9-10	721	74	436	231	20
10-11	811	90	532	260	20
11-12	868	33	590	277	20
12-13	893	16	588	305	20
13-14	868	49	582	320	20
14-15	969	33	515	303	19
15-16	614	16	400	230	19
16-17	451	8	268	158	19
17-18	254	0	128	90	19
18-19	82	0	28	28	18
19-20	0	0	0	0	30
20-21	0	0	0	0	30
21-22	0	0	0	0	30
22-23	0	0	0	0	30
23-24	0	0	0	0	30

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month(s): MAY 1977
JUN 1979

Solar Flux (Watts/Sq.M.)

Hour	Maximum	Minimum	Average	Standard Deviation	# of Data Points
3- 4	0	0	0	0	52
4- 5	2	0	0	1	53
5- 6	7	0	1	2	53
6- 7	111	1	33	30	54
7- 8	332	8	145	83	54
8- 9	545	25	291	132	55
9-10	833	49	452	183	57
10-11	911	49	577	211	53
11-12	915	82	633	232	53
12-13	950	71	727	253	53
13-14	1003	74	717	235	53
14-15	853	32	599	251	53
15-16	913	71	595	246	53
16-17	745	49	439	197	53
17-18	539	32	365	152	53
18-19	414	32	221	105	53
19-20	221	4	95	52	53
20-21	57	0	17	15	53
21-22	4	0	0	1	53
22-23	0	0	0	0	52
23-24	0	0	0	0	52

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month(s): JUNE 1977
JUNE 1978

JUNE 1979

Solar Flux (Watts/Sq.M.)

Hour	Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	19	0	1	5	39
4- 5	49	0	2	7	31
5- 6	91	0	5	12	31
6- 7	150	0	55	37	30
7- 8	328	2	165	95	29
8- 9	492	16	239	149	32
9-10	855	41	426	204	33
10-11	940	97	559	213	33
11-12	925	45	521	253	35
12-13	1059	45	579	283	35
13-14	1010	65	705	279	35
14-15	1005	49	643	274	35
15-16	897	65	533	251	36
16-17	773	49	481	229	37
17-18	771	34	375	187	37
18-19	523	16	257	131	37
19-20	336	4	143	74	37
20-21	328	0	43	41	35
21-22	30	0	2	4	37
22-23	0	0	0	0	39
23-24	0	0	0	0	39

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month(s): JULY 1977
JULY 1978
JULY 1979

Solar Flux (Watts/Sq.M.)

Hour	Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	3	0	0	1	93
4- 5	3	0	0	1	91
5- 6	15	0	2	3	91
6- 7	151	0	44	32	90
7- 8	346	8	142	79	91
8- 9	530	8	256	137	91
9-10	642	25	405	176	92
10-11	845	37	534	213	92
11-12	945	41	595	243	92
12-13	1123	33	550	260	91
13-14	999	94	651	271	91
14-15	967	103	653	243	93
15-16	804	41	593	232	93
16-17	807	41	529	197	93
17-18	563	16	414	155	93
18-19	515	12	274	113	92
19-20	347	10	140	73	93
20-21	164	0	40	39	93
21-22	25	0	2	5	93
22-23	0	0	0	0	93
23-24	0	0	0	0	93

UNIVERSITY OF THE DISTRICT OF COLUMBIA

COLUMBIA ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month(s): AUGUST 1977
AUGUST 1978
AUGUST 1979

Solar Flux (Watts/Sq.M.)

Hour	Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	13	0	0	2	75
4- 5	13	0	1	2	75
5- 6	33	0	4	9	75
6- 7	164	0	35	51	73
7- 8	343	0	121	107	73
8- 9	543	0	254	151	74
9-10	756	0	373	203	74
10-11	821	23	476	244	74
11-12	880	56	550	255	74
12-13	989	74	589	230	74
13-14	934	41	500	276	74
14-15	850	49	542	250	74
15-16	771	8	477	233	74
16-17	555	24	339	194	72
17-18	598	8	293	155	72
18-19	598	0	176	112	72
19-20	553	0	58	81	72
20-21	283	0	15	33	72
21-22	150	0	2	13	72
22-23	0	0	0	0	93
23-24	0	0	0	0	93

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month: SEPTEMBER 1978

Hour	Solar Flux (Watts/Sq.M.) Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	0	0	0	0	30
4- 5	0	0	0	0	30
5- 6	0	0	0	0	30
6- 7	0	0	0	0	30
7- 8	74	0	25	21	30
8- 9	246	0	106	85	30
9-10	451	8	222	155	30
10-11	598	25	294	200	30
11-12	721	33	373	240	30
12-13	770	33	415	275	30
13-14	901	16	431	284	30
14-15	836	25	403	266	30
15-16	713	25	350	212	30
16-17	565	16	265	184	30
17-18	360	8	166	123	30
18-19	205	0	65	53	30
19-20	49	0	9	14	30
20-21	0	0	0	0	30
21-22	0	0	0	0	30
22-23	0	0	0	0	30
23-24	0	0	0	0	30

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month: OCTOBER 1978

Hour	Solar Flux (Watts/Sq.M.) Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	0	0	0	0	31
4- 5	0	0	0	0	31
5- 6	0	0	0	0	31
6- 7	0	0	0	0	31
7- 8	82	0	7	18	31
8- 9	262	0	64	57	31
9-10	393	16	147	104	31
10-11	475	25	243	147	31
11-12	573	25	294	158	31
12-13	606	25	324	187	31
13-14	623	16	330	199	30
14-15	623	16	306	194	31
15-16	623	16	244	172	31
16-17	410	16	159	123	31
17-18	270	0	80	76	31
18-19	123	0	12	24	31
19-20	0	0	0	0	31
20-21	0	0	0	0	31
21-22	0	0	0	0	31
22-23	0	0	0	0	31
23-24	0	0	0	0	31

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month: NOVEMBER 1978

Hour	Solar Flux (Watts/Sq.M.) Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	0	0	0	0	30
4- 5	0	0	0	0	30
5- 6	0	0	0	0	30
6- 7	0	0	0	0	30
7- 8	33	0	9	10	30
8- 9	180	0	64	51	30
9-10	295	0	149	92	30
10-11	491	16	222	125	30
11-12	524	16	264	152	30
12-13	541	16	265	154	30
13-14	410	8	229	134	30
14-15	328	0	165	101	30
15-16	213	0	84	66	30
16-17	90	0	22	29	30
17-18	8	0	1	2	30
18-19	0	0	0	0	30
19-20	0	0	0	0	30
20-21	0	0	0	0	30
21-22	0	0	0	0	30
22-23	0	0	0	0	30
23-24	0	0	0	0	30

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month: DECEMBER 1978

Hour	Solar Flux (Watts/Sq.M.) Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	0	0	0	0	31
4- 5	0	0	0	0	31
5- 6	0	0	0	0	31
6- 7	0	0	0	0	31
7- 8	0	0	0	0	31
8- 9	57	0	12	20	29
9-10	213	0	76	58	29
10-11	361	25	147	92	29
11-12	426	25	190	94	29
12-13	385	16	214	99	29
13-14	328	8	185	83	28
14-15	287	8	135	71	28
15-16	197	0	60	49	28
16-17	41	0	3	9	28
17-18	0	0	0	0	31
18-19	0	0	0	0	31
19-20	0	0	0	0	31
20-21	0	0	0	0	31
21-22	0	0	0	0	31
22-23	0	0	0	0	31
23-24	0	0	0	0	31

UNIVERSITY OF [illegible] ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month(s): JUNE 1977
JUNE 1978
JUNE 1979
JULY 1977
JULY 1978
JULY 1979
AUGUST 1977
AUGUST 1978
AUGUST 1979

Solar Flux (Watts/Sq.M.)

Hour	Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	19	0	1	3	298
4- 5	49	0	1	4	248
5- 6	91	0	3	9	248
6- 7	134	0	45	40	243
7- 8	346	0	143	95	243
8- 9	543	0	270	143	247
9-10	833	0	403	194	249
10-11	996	23	522	234	249
11-12	985	41	591	250	252
12-13	1123	33	642	275	251
13-14	1010	41	554	278	250
14-15	1006	49	617	262	253
15-16	997	8	557	245	253
16-17	807	24	469	211	252
17-18	771	8	366	174	252
18-19	599	0	240	127	251
19-20	553	0	121	83	252
20-21	323	0	36	39	251
21-22	150	0	2	10	252
22-23	0	0	0	0	275
23-24	0	0	0	0	275

Section A5(b)

[illegible] OF THE [illegible]

[illegible] ENVIRONMENTAL STUDY

[illegible] FLUX ANALYSIS:

Month(s): [illegible] 1977
[illegible] 1978
[illegible] 1979
[illegible] 1977
[illegible] 1978
[illegible] 1979
[illegible] 1977
[illegible] 1978

Solar Flux (ergs/Sq.".)

Hour	Maximum	Minimum	Average	Standard Deviation	% of Data Points
1- 4	3	0	1	1	90
4- 5	35	0	1	4	85
5- 6	91	0	5	12	86
6- 7	168	0	60	34	83
7- 8	343	8	125	91	84
8- 9	523	16	331	114	85
9-10	639	82	493	153	87
10-11	807	85	626	171	87
11-12	926	118	714	184	86
12-13	1123	144	770	184	88
13-14	999	123	782	212	87
14-15	956	126	721	194	84
15-16	897	82	640	191	89
16-17	807	24	505	175	90
17-18	771	8	336	149	89
18-19	516	0	259	110	89
19-20	327	0	129	63	89
20-21	164	0	38	23	90
21-22	25	0	2	4	90
22-23	0	0	0	0	93
23-24	0	0	0	0	93

[illegible]

[illegible]

SOLAR FLUX ANALYSIS:

[illegible]orth(s): [illegible] 1977
[illegible] 1979

Solar Flux (Watts/Sq.M.)

Hour	Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	0	0	0	0	21
4- 5	2	0	0	1	20
5- 6	7	0	1	2	20
6- 7	111	2	44	40	20
7- 8	332	25	158	98	20
8- 9	545	49	312	153	21
9-10	648	82	454	213	21
10-11	799	131	557	238	21
11-12	825	137	689	257	21
12-13	953	194	714	284	21
13-14	983	212	777	282	21
14-15	969	225	757	241	21
15-16	933	117	592	251	21
16-17	715	105	504	208	21
17-18	530	114	378	154	21
18-19	413	32	227	112	21
19-20	221	4	95	69	21
20-21	57	0	29	20	21
21-22	4	0	0	1	21
22-23	0	0	0	0	21
23-24	0	0	0	0	21

[illegible]

[illegible]

SOLAR FLUX ANALYSIS:

Month(s): [illegible] 1977
[illegible] 1978
[illegible] 1979

Solar Flux (Watts/Sq.M.)

Hour	Maximum	Minimum	Average	Standard deviation	# of Data Points
1- 4	8	0	1	2	42
4- 5	35	0	2	6	42
5- 6	91	0	6	15	42
6- 7	160	0	69	38	38
7- 8	323	21	211	95	38
8- 9	491	45	349	147	38
9-10	639	41	522	212	40
10-11	795	97	644	264	40
11-12	913	45	731	301	42
12-13	986	45	816	334	42
13-14	1010	78	933	331	41
14-15	979	81	758	349	41
15-16	889	108	673	277	41
16-17	773	49	523	213	42
17-18	771	34	401	171	42
18-19	463	16	272	120	42
19-20	336	4	149	69	42
20-21	150	3	49	29	42
21-22	30	0	2	5	42
22-23	0	0	0	0	42
23-24	0	0	0	0	42

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month(s): JULY 1977
JULY 1978
JULY 1979

Solar Flux (Watts/Sq.M.)

Hour	Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	8	0	1	2	33
4- 5	8	0	0	2	31
5- 6	12	0	1	4	31
6- 7	135	0	43	34	30
7- 8	273	62	152	69	31
8- 9	454	115	296	111	31
9-10	636	109	458	150	32
10-11	771	47	591	170	32
11-12	907	50	666	220	32
12-13	1123	180	696	250	31
13-14	999	115	712	251	31
14-15	967	121	673	254	33
15-16	861	41	614	252	33
16-17	768	41	528	213	33
17-18	617	64	421	153	33
18-19	492	32	286	121	32
19-20	292	13	144	73	33
20-21	135	0	41	32	33
21-22	25	0	2	5	33
22-23	0	0	0	0	33
23-24	0	0	0	0	33

MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month(s): AUGUST 1977
AUGUST 1978

Solar Flux (Watts/Sq.M.)

Hour	Maximum	Minimum	Average	Standard Deviation	# of Data Points
1- 4	2	0	1	1	16
4- 5	2	0	1	1	15
5- 6	37	0	10	14	15
6- 7	164	2	74	62	15
7- 8	343	31	190	112	15
8- 9	523	99	353	142	15
9-10	681	195	488	180	15
10-11	807	285	654	151	15
11-12	889	500	770	133	15
12-13	899	417	794	121	15
13-14	902	376	799	166	15
14-15	845	346	728	162	15
15-16	771	361	590	116	15
16-17	533	24	405	161	15
17-18	434	8	325	129	15
18-19	246	0	168	79	15
19-20	94	0	40	28	15
20-21	8	0	2	3	15
21-22	2	0	0	1	15
22-23	0	0	0	0	16
23-24	0	0	0	0	16

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MINISTRY OF THE ENVIRONMENT

SUDBURY ENVIRONMENTAL STUDY

SOLAR FLUX ANALYSIS:

Month(s): SEPTEMBER 1978

1- 4	0	0	0	0	6
4- 5	0	0	0	0	6
5- 6	0	0	0	0	6
6- 7	0	0	0	0	6
7- 8	66	8	34	12	6
8- 9	229	33	137	79	6
9-10	413	74	283	134	6
10-11	533	82	406	186	6
11-12	705	287	519	161	6
12-13	770	377	601	155	6
13-14	778	393	608	129	6
14-15	770	377	662	144	6
15-16	664	139	523	199	6
16-17	549	270	429	97	6
17-18	360	57	258	104	6
18-19	130	25	101	52	6
19-20	25	0	10	11	6
20-21	0	0	0	0	6
21-22	0	0	0	0	6
22-23	0	0	0	0	6
23-24	0	0	0	0	6

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